RECEIVED
JUL 1 '66
U.S. PUBLIC HEALTH SERVICE

Med. Lib.

Radiological Health Data and Reports

VOLUME 7, NUMBER 5
MAY 1966
(Pages 257-318)

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 7, Number 5 May 1966

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the Division of Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the Division of Radiological Health by Federal agencies, State health departments, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators. These are subject to review by a Board of Editorial Advisors with representatives from the following Federal agencies:

Department of Defense
Department of Agriculture
Department of Commerce
Department of Health, Education, and Welfare
Atomic Energy Commission

CONTENTS

REPORTS

Page

Disposal of Radioactive Wastes from U.S. Naval Nuclear-Powered Ships and Their Support Facilities 257
J. W. Vaughan and *M. E. Miles*

The Galveston Environmental Surveillance Program, 1965 .. 263
D. H. Flora and *M. C. Wukasch*

DATA

SECTION I. MILK AND FOOD 269

National and International Milk Surveillance 270
(including list of other programs previously reported)

1. Pasteurized Milk Network, January 1966, *PHS* 270
2. Canadian Milk Network, January 1966 273
3. Pan American Milk Sampling Program, January 1966, *PAHO* and *PHS* 274

State Milk Surveillance Activities (including list of other State programs previously reported) 275

1. Connecticut Milk Network, October–December and Annual Summary 1965 275
2. Indiana Milk Network, October–December and Annual Summary 1965 277
3. Michigan Milk Network, October–December and Annual Summary 1965 278
4. Minnesota Milk Network, July–December and Annual Summary 1965 281
5. New York Milk Network, July–December and Annual Summary 1965 283

CONTENTS—continued

Page

6. Pennsylvania Milk Network, October–December and Annual Summary 1965 286

Food and Diet Surveillance Activities 288
(including list of programs previously reported)

1. Radionuclides in Institutional Diet Samples, July–September 1965, *PHS* 288

SECTION II. WATER 293
(including list of programs previously reported)

Gross Radioactivity in Surface Waters of the United States, November 1965, *FWPCA* 294

Radioactivity in Washington Surface Water, July 1964–June 1965 296

SECTION III. AIR AND DEPOSITION 301

Radioactivity in Airborne Particulates and Precipitation (including list of programs previously reported) 301

1. Radiation Surveillance Network, January 1966, *PHS* 302
2. Canadian Air and Precipitation Monitoring Program, January 1966 305
3. Pan American Air Sampling Program, January 1966, *PAHO* and *PHS* 306
4. Fallout in the United States and Other Areas, January–June 1965, *AEC* 307

SECTION IV. OTHER DATA 311

Environmental Levels of Radioactivity at Atomic Energy Commission Installations 311

1. Lawrence Radiation Laboratory, January–June 1965 311
2. Mound Laboratory, January–June 1965 314

SECTION V. TECHNICAL NOTES 316

Reported Nuclear Detonations, April 1966 316

Synopses 317

Symbols, Units, and Equivalents ..... Inside back cover

RADIOLOGICAL HEALTH DATA AND REPORTS

Published under the direction of

Dr. Donald R. Chadwick, Chief, and James G. Terrill, Deputy Chief
Division of Radiological Health

by the Radiation Surveillance Center, DRH
Donald L. Snow, Chief

BOARD OF EDITORIAL ADVISORS

Dr. Gerrit L. Hekhuis
Department of Defense
Dr. Ronald G. Menzel
Department of Agriculture
Dr. Harold O. Wyckoff
Department of Commerce
Dr. William Horwitz
Food & Drug Administration, DHEW
Mr. Philippe G. Jacques
Atomic Energy Commission

STAFF

Managing Editor
Samuel Wieder
Assistant Managing Editor
Walter W. Davenport
Senior Editor
James R. Coleman
Technical Editors
Robert P. Chandler
Kurt L. Feldmann
Richard D. Grundy

Address correspondence to the Managing Editor, Radiation Surveillance Center, Division of Radiological Health, Public Health Service, Washington, D.C. 20201.

For further information on any subject reported in this issue, readers are referred to the contributors indicated in article headings.

For subscriptions to *Radiological Health Data and Reports*, please use the order form on last page of this issue.

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service Division of Radiological Health

DISPOSAL OF RADIOACTIVE WASTES FROM U.S. NAVAL NUCLEAR-POWERED SHIPS AND THEIR SUPPORT FACILITIES

J. W. Vaughan and *M. E. Miles*[1]

SYNOPSIS—This report presents data on disposal of radioactive wastes from U.S. Naval nuclear-powered ships and their support facilities and summarizes results of environmental monitoring performed to confirm adequacy of waste disposal limits and procedures. The waste disposal data presented show that the total long-lived radioactivity in liquid waste discharges associated with operation and maintenance of Naval nuclear-powered ships has been less than 2 curies per year in any harbor. Results of environmental surveys of harbor water and bottom sediment for gross radioactivity and for cobalt-60 have shown that (1) no increase in radioactivity above normal background levels has been detected in harbor water, (2) discharges of liquid wastes from U.S. naval nuclear-powered ships have not caused a measurable increase in the general external background radioactivity of the environment, and (3) low-level cobalt-60 radioactivity has been detected in localized areas of harbor bottom sediment around a few piers at operating bases and shipyards where maintenance and overhaul of Naval nuclear-powered ships have been conducted over a period of several years.

This report confirms that procedures issued by the Navy to control discharges of radioactivity from U.S. Naval nuclear-powered ships and their support facilities are effective in protecting the health and safety of the general public. These Navy procedures, which have been reviewed and concurred in by the U.S. Public Health Service and the U.S. Atomic Energy Commission, contain discharge limits which are consistent with applicable recommendations of the Federal Radiation Council, U. S. Atomic Energy Commission, and the International Commission on Radiological Protection.

The radioactivity in wastes discussed in this report originates in the pressurized water reactors of U.S. Naval nuclear-powered ships. As of January 1966, there were 56 nuclear-powered submarines and 3 nuclear-powered surface ships in operation. In these shipboard reactors, pressurized water circulating through the reactor core picks up the heat of nuclear reaction. Reactor cooling water circulates through a closed piping system including heat exchangers which transfer the heat to water in a separate secondary steam system; the steam is then used as the source of power for the propulsion plant as well as for auxiliary machinery. Discharges from ships occur primarily when reactor coolant water expands as a result of heating a reactor plant to operating temperature; this coolant passes through a purification system ion-exchange resin bed prior to discharge.

Construction, maintenance, overhaul, and refueling of these nuclear propulsion plants involve various shipyards, submarine tenders, and submarine bases. Liquid wastes discharged at these support facilities result from operations such as draining shipboard reactor

[1] Nuclear Propulsion Division, Bureau of Ships, Department of the Navy, Washington, D.C.

systems, decontaminating radioactively contaminated piping systems, and laundering anticontamination clothing worn by personnel. These facilities are equipped with processing systems to remove most of the radioactivity from liquid wastes prior to discharge into harbors.

Discharge limits for the low-level radioactive liquid wastes from U.S. Naval nuclear-powered ships and their support facilities are consistent with applicable recommendations issued by the Federal Radiation Council, U.S. Atomic Energy Commission (AEC), National Council on Radiation Protection and Measurements (NCRP), International Commission on Radiological Protection (ICRP), and National Academy of Sciences—National Research Council (*1–5*). In consonance with these recommendations the policy of the U.S. Navy is to minimize the amounts of radioactivity discharged into harbors. To implement this policy, the Navy has issued standard instructions defining the radioactive waste disposal limits and procedures to be used by U.S. Naval nuclear-powered ships and their support facilities. These instructions have been reviewed and concurred in by the U.S. Public Health Service and the U.S. Atomic Energy Commission.

The principal source of radioactivity in liquid wastes is from trace amounts of corrosion and wear products from reactor plant metal surfaces. The most predominant long-lived radionuclide (i.e., half-life greater than 1 day) in these corrosion and wear products is cobalt–60, which has a 5.3 year half-life; cobalt–60 also has the lowest maximum permissible concentration value for water listed by the AEC, NCRP, and ICRP for these corrosion and wear radionuclides (*2–4*). Therefore, radioactive waste disposal is controlled by assuming that all the long-lived radioactivity is cobalt–60. Short-lived radionuclides decay rapidly and are therefore less limiting than long-lived radioactivity for waste disposal considerations.

Fission products produced by the fission process of the reactor are retained metallurgically bound within the fuel alloy. As a result, the total radioactivity attributed to long-lived fission product radionuclides strontium–90 and cesium–137 in discharges from U.S. Naval nuclear-powered ships and their support facilities has been less than 1 millicurie per year for all harbors combined.

Table 1 lists volumes of liquid and total amounts of long-lived radioactivity discharged into various U.S. harbors during the past 5 calendar years; included are data from U.S. Naval nuclear-powered ships and from supporting shipyards, tenders, and submarine bases. Locations listed in table 1 include operating bases and home ports which have been regularly visited by Naval nuclear-powered ships. The quantities of radioactivity listed in this table are reported as if the entire radioactivity consisted of cobalt–60, the predominant long-lived radionuclide.

Liquid waste discharges reported in table 1 vary with the amount of overhaul and maintenance work in progress at individual locations. In spite of a large increase in overhaul work in 1965, the total radioactivity discharged was kept to levels comparable with previous years by effecting improvements in waste processing techniques. The low amounts of radioactivity in table 1 discharged by each facility are comparable to amounts discharged into rivers by a number of other facilities in the United States involved in nuclear power programs where stringent waste disposal controls similar to those used by the Navy are enforced.

During maintenance and overhaul operations, solid low-level radioactive wastes consisting of contaminated rags, plastic bags, paper, and scrap materials are collected by nuclear-powered ships and their support facilities. Solid materials from ships are transferred to a shipyard or other shore facility for packaging and disposal. For ultimate disposal, solid radioactive wastes are shipped to AEC approved burial sites, since shipyards and shore facilities are not permitted to dispose of radioactive solid wastes by burial on their own sites. Table 2 summarizes total radioactivity and volumes of radioactive wastes disposed of in the past 5 years.

Environmental monitoring

Environmental monitoring surveys for radioactivity are periodically performed in harbors where U.S. Naval nuclear-powered ships are built or overhauled and where these ships have

Table 1. Radioactive liquid waste discharges to U.S. harbors from U.S. Naval nuclear-powered ships and their support facilities for 1961 through 1965

Location	1961		1962		1963		1964		1965		5-year total curies
	Thousand gallons	Curies	Thousand gallons	Curies	Thousand gallons	Curies	Thousand gallons	Curies	Thousand gallons	Curies	
1. Portsmouth, New Hampshire Naval Shipyard	39	0.01	1,344	0.07	112	0.03	407	0.13	204	0.24	0.48
2. Quincy, Massachusetts Electric Boat Division	59	0.01	22	0.05	104	0.09	0	0	0	0	0.15
3. Groton-New London, Connecticut Electric Boat Division, State Pier, and Submarine Base	166	0.87	110	1.40	101	1.69	201	1.93	828	1.29	7.18
4. Camden, New Jersey New York Shipbuilding Corp	0	0	66	0.01	0	0	0	0	0	0	0.01
5. Newport News, Virginia Newport News Shipbuilding	445	0.18	460	0.18	21	0.01	965	0.24	3,360	1.70	2.31
6. Norfolk, Virginia Naval Shipyard and Base	0	0	0	0	300	0.07	337	0.61	1,146	0.44	1.17
7. Charleston, South Carolina Naval Shipyard and Base	11	0.01	31	0.01	246	0.14	294	0.36	717	0.67	1.19
8. Pascagoula, Mississippi Ingalls Shipbuilding Corp	0	0	0	0	0	0	0	0	0	0	0
9. San Diego, California Navy Piers, Ballast Point	5	0.01	0	0	34	0.25	35	0.40	40	0.33	0.99
10. Vallejo, California S.F. Bay Naval Shipyard	14	0.02	100	0.93	65	0.55	63	0.62	128	0.21	2.33
11. Bremerton, Washington Puget Sound Naval Shipyard	0	0	0	0	1	0.02	0	0	196	0.01	0.03
12. Pearl Harbor, Hawaii Naval Shipyard and Base	25	0.10	258	0.72	594	0.92	405	0.98	548	0.48	3.20
13. Apra Harbor, Guam	0	0	0	0	0	0	0	0	69	0.01	0.01
Totals	764	1.21	2,391	3.37	1,578	3.77	2,707	5.27	7,236	5.38	19.05

Notes:
(1) U.S. harbors where shipyards and operating bases for nuclear-powered ships are located are included. Other U.S. harbors have had less than 20 thousand gallons and less than 0.1 curie discharged per year.
(2) Where discharges in one harbor for a year totaled less than 0.005 curies, "0" is reported in this table.
(3) Radioactivity data has been standardized to cobalt-60. Volumes are reported prior to dilution.

home ports or operating bases. These surveys are performed to verify the adequacy of liquid waste disposal procedures and limits.

Shipyards, tenders, and submarine bases have taken weekly samples of harbor water and bottom sediment in the vicinity of berths used by nuclear-powered ships, beginning in each harbor prior to operation of these ships. Radioactivity data from harbor water and sediment samples taken by individual facilities indicate that operation and maintenance of nuclear-powered ships have not caused significant changes in the gross radioactivity of harbor water or sediment. However, relatively large variations in gross radioactivity measured in environmental samples do occur from changes in natural and fallout sources. Because of these variations, monitoring for gross radioactivity in harbor water and sediment is not sufficient to detect small changes in environmental radioactivity which might be attributed to operation and maintenance of Naval nuclear-powered ships.

To monitor for these small changes in environmental radioactivity, specific analyses of water and sediment samples for cobalt–60 have been added to Navy monitoring programs in recent years. Cobalt–60 is a sensitive tracer to follow environmental distribution of radioactivity because it has the longest half-life and is the predominant long-lived radionuclide in liquid waste discharges; in addition, cobalt–60 has not been detected in significant concentrations in radioactivity from fallout or natural sources.

Therefore, starting in 1963, a bottom sedi-

Table 2. Radioactive solid waste disposed of by facilities supporting U.S. Naval nuclear-powered ships for 1961 through 1965

Facility	1961		1962		1963		1964		1965	
	Hundred cubic feet	Curies	Hundred cubic feet	Curies	Hundred cubic feet	Curies	Hundred cubic feet	Curies	Hundred cubic feet	Curies
1. Portsmouth, New Hampshire Naval Shipyard	4	0	80	0.5	15	0.5	80	2.6	150	2.6
2. Quincy, Massachusetts Electric Boat Division	0	0	0	0	0	0	0	0	0	0
3. Groton-New London, Connecticut Electric Boat Division, Tender at State Pier, and Submarine Base	138	39.1	85	1.5	102	1.1	99	2.3	155	353.0
4. Camden, New Jersey New York Shipbuilding Corp	0	0	0	0	0	0	0	0	0	0
5. Newport News, Virginia Newport News Shipbuilding	1	0	10	0.1	8	0.3	22	1.8	198	28.0
6. Norfolk, Virginia Naval Shipyard and Tender	0	0	0	0	3	0	5	0.5	33	1.6
7. Charleston, South Carolina Naval Shipyard and Tenders	5	5.0	9	1.1	35	0.4	47	1.0	78	111.5
8. Pascagoula, Mississippi Ingalls Shipbuilding Corp	0	0	0	0	0	0	0	0	0	0
9. San Diego, California Tenders at Ballast Point	0	0	0	0	2	0.1	7	7.5	3	0
10. Vallejo, California S.F. Bay Naval Shipyard	12	4.3	52	6.0	35	19.0	9	0.3	47	9.4
11. Bremerton, Washington Puget Sound Naval Shipyard	0	0	0	0	0	0	0	0	4	0.1
12. Pearl Harbor, Hawaii Naval Shipyard and Base	0	0	0	0	16	0.4	13	0.7	8	1.4
Totals	160	48.4	236	9.2	216	21.8	282	16.7	676	507.6

Notes:
(1) Where total radioactivity is less than 0.05 curies, "0" is reported in this table.
(2) This table also includes waste from tenders and nuclear-powered ships.

ment sample taken in each harbor from the vicinity of nuclear-powered ship berths was analyzed for cobalt–60 to supplement the gross radioactivity measurements described above. This additional sampling was performed in cooperation with the U.S. Public Health Service (USPHS), and analyses were performed at their Southeastern Radiological Health Laboratory. Results of USPHS analyses for cobalt–60 in harbor bottom sediment samples taken from the vicinity of nuclear-powered ship berths are shown in table 3. Since each number in table 3 is the result of a single sample, more extensive sampling, discussed below, was deemed necessary to determine whether the isolated data points were representative of the surrounding harbor bottom sediment.

To obtain more representative data and to evaluate the cumulative effect of liquid waste discharges over the preceding years, extensive environmental surveys were performed commencing in July 1965. Cobalt–60 analyses were performed on 20 to 70 bottom sediment samples taken from each harbor where Naval nuclear-powered ships have been most frequently based or overhauled; these samples were taken from the top layer of sediment (approximately 1 inch thick) in the immediate vicinity of and away from berthing areas used by Naval nuclear-powered ships. Results of these July 1965 surveys, which involved a total of 345 samples, are summarized in table 4. These surveys show that the total amount of cobalt–60 observed in bottom sediment near a few piers is small compared to natural radioactivity present in harbors.

In conjunction with the bottom sediment sampling surveys reported in table 4, nearby shoreline areas uncovered at low tide were surveyed with sensitive beta-gamma detectors to determine if any of the discharged radioactivity had washed ashore. No shoreline

Table 3. U.S. Public Health Service analyses of cobalt-60 in harbor bottom sediment in vicinity of berths used by U.S. Naval nuclear-powered ships [a]

Location	Picocuries of cobalt-60 per gram of ashed sediment						
	Nov 1963	July 1964	Oct 1964	Jan 1965	Apr 1965	July 1965	Oct 1965
1. Portsmouth, New Hampshire Naval Shipyard	1	6	4	5	0	2	0
2. Quincy, Massachusetts Electric Boat Division	1	1	0	0	0	0	0
3. Groton, Connecticut Electric Boat Division	4	7	12	25	8	380	5
4. Camden, New Jersey New York Shipbuilding Corp	0	0	0	0	0	0	0
5. Newport News, Virginia Newport News Shipbuilding	22	0	0	0	0	2	0
6. Norfork, Virginia Naval Shipyard	0	0	0	0	0	0	14
7. Charleston, South Carolina Naval Shipyard	1	2	0	3	0	5	0
8. Pascagoula, Mississippi Ingalls Shipbuilding Corp	0	0	0	0	0	0	10
9. San Diego, California Navy Piers, Ballast Point	No sample	54	3	43	90	9	2
10. Vallejo, California S.F. Bay Naval Shipyard	1	1	0	128	3	2	0
11. Bremerton, Washington Puget Sound Naval Shipyard	1	0	0	0	0	0	0
12. Pearl Harbor, Hawaii Naval Shipyard	22	33	270	63	75	37	40
13. Apra Harbor, Guam [b]	No sample	No sample	No sample	0	0	0	0

[a] Each number is the result of a single sample and therefore may not be representative of the harbor bottom sediment around nuclear-powered ship berths. Results of more extensive sampling are in table 4. "0" indicates no cobalt-60 detected.
[b] Use of Apra Harbor, Guam as an operating base commenced January 1965.

radiation levels above the normal 0.01 to 0.03 millirem per hour background levels were detected in any of these locations.

In addition to the locations listed in table 4, environmental monitoring has been accomplished by U.S. Navy submarine tenders which serve as operating bases for U.S. Naval nuclear-powered submarines in Rota, Spain, and Holy Loch, Scotland. Data from these surveys have been exchanged with the host governments. Results of the surveys in the harbor at Rota, Spain, have not shown detectable cobalt–60 in harbor bottom sediment samples. In the Holy Loch, Scotland, anchorage more cobalt–60 radioactivity has been detected in harbor bottom sediment than was expected. Some slight increase in cobalt–60 radioactivity has also been found near the tender anchorage in Holy Loch on shoreline mud flat areas uncovered at low tide. However, there has been no increase of harbor water radioactivity in Holy Loch above normal background levels. Joint U.S. and British assessments of survey results have confirmed that radiation levels in the vicinity of the Holy Loch anchorage are still far below those which are at all likely to cause an individual to receive radiation exposure approaching limits for members of the general public.

Overall results of environmental surveys performed to date indicate the following:

(1) No increase in gross radioactivity above normal background levels has been detected in habor water where U.S. Naval nuclear-powered ships are based, overhauled, or constructed.

(2) Discharges of liquid wastes from U.S. Naval nuclear-powered ships have not caused a measurable increase in the general external background radioactivity of the environment.

(3) Low level cobalt–60 radioactivity in harbor bottom sediment is detectable around a few

Table 4. Summary of cobalt-60 in bottom sediment of U.S. harbors where U.S. Naval nuclear-powered ships have been regularly based or overhauled as surveyed in July 1965

Location	Total bottom area [a] with detectable cobalt-60 (square kilometers) [b]	Average cobalt-60 concentration in detectable area (picocuries cobalt-60/ square centimeter)	Estimated total cobalt-60 on bottom (curies)
1. Portsmouth, New Hampshire Naval Shipyard	—	Not detectable	Not detectable
2. Groton-New London, Connecticut Electric Boat Division, State Pier, and Submarine Base	0.1	190	0.19
3. Newport News, Virginia Newport News Shipbuilding	—	Not detectable	Not detectable
4. Norfolk, Virginia Naval Base	—	Not detectable	Not detectable
5. Charleston, South Carolina Naval Shipyard and Base	—	Not detectable	Not detectable
6. San Diego, California Navy Piers at Ballast Point	0.01	30	0.003
7. Vallejo, California S.F. Bay Naval Shipyard	0.01	10	0.001
8. Pearl Harbor, Hawaii Naval Shipyard and Base	0.3	10	0.03
9. Apra Harbor, Guam	—	Not detectable	Not detectable

[a] All areas with detectable cobalt-60 were in immediate vicinity of piers used for berthing nuclear-powered ships.

[b] One square kilometer is approximately equal to 0.4 square miles; 1 picocurie = 10^{-12} curies.

specific piers at operating bases and shipyards where nuclear-powered submarine maintenance and overhauls have been conducted over a period of several years. Cobalt–60 is not detectable above background levels in general harbor bottom areas away from these piers. Maximum total radioactivity observed in a U.S. harbor is less than 1 curie of cobalt–60.

REFERENCES

(*1*) FEDERAL RADIATION COUNCIL. Federal Radiation Council memoranda, approved by President Eisenhower on May 13, 1960, and by President Kennedy on September 20, 1961.

(*2*) U.S. ATOMIC ENERGY COMMISSION. Standards for protection against radiation. Code of Federal Regulations, Title 10, Part 20.

(*3*) NATIONAL COUNCIL OF RADIATION PROTECTION AND MEASUREMENTS. Maximum permissible body burdens and maximum permissible concentrations of radionuclides in air and in water for occupational exposure. National Bureau of Standards Handbook 69 (June 1959).

(*4*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Report of Committee II on permissible dose for international radiation, 1959. Also ICRP Supplement 6 (1962); ICRP Publication 2 (1959).

(*5*) NATIONAL ACADEMY OF SCIENCES — NATIONAL RESEARCH COUNCIL. Radioactive waste disposal from nuclear-powered ships, Publication 658. National Academy of Sciences—National Research Council, Washington, D.C. (1959).

THE GALVESTON ENVIRONMENTAL SURVEILLANCE PROGRAM, 1965

David H. Flora and *Martin C. Wukasch*[1]

SYNOPSIS—Environmental surveillance between March 10 and August 20, 1965, at the Galveston refueling and servicing site for the Nuclear Ship Savannah indicated no detectable radioactive contamination attributable to the ship's operations. Surveillance activities which have continued at this site since 1962, include air, rain, sea water, silt, shellfish (oysters), and milk sampling. During the Savannah's 1965 visit, almost all analytical results for environmental samples were close to or below detectable limits, except for milk. Radioactivity trends in milk samples at this time closely followed the nationwide trend reported by the U.S. Public Health Service.

With the selection of Todd Shipyards on Pelican Island, Galveston, Texas, as the refueling and servicing site for the Nuclear Ship Savannah, the Texas State Department of Health and the U.S. Public Health Service cooperatively initiated the Galveston Environmental Surveillance Program. The program was begun in June 1962, some 6 months prior to the first arrival of the ship at the Pelican Island site, and has continued subsequently.

Previous reports have been distributed covering the first and second years of the sampling program.[2] These reports included the sampling schedule, type of samples collected, location of sampling stations, and results of the analyses of samples collected during that time. This report is for the purpose of providing essentially the same information for that portion of 1965 when the ship was in Galveston Harbor. The N.S. Savannah arrived in Galveston Harbor, March 10, 1965, and after a short period on public exhibition was docked at Todd Shipyards for repairs and modification until departure August 20, 1965.

Sample collection and analyses

Air samples were collected three times a week. Sample station locations are shown in figure 1. The schedule of sample collection for the period is shown in table 1. The high-volume air samplers operate intermittently on an hour-on hour-off basis.

Seawater is collected by means of an intermittently operated peristaltic pump on an hour-on, 5-hour-off basis: i.e., 4 hourly samples are collected each day. The samples are accumulated in this manner for 2 weeks. At the end of this period, 4 liters of the composited sample are submitted to the laboratory for analysis.

Silt samples were collected from the bottom of the Galveston Channel at stations 10 and 11, by means of a spring-activated, hand-operated silt dredge. Samples were collected immediately prior to the N.S. Savannah's arrival, and again after its departure. Samples in the amount of 4 liters each were submitted to the laboratory for analysis.

[1] Mr. Flora is supervisor, Surveillance Activities, and Mr. Wukasch is chief, Radiation Control Program, Division of Occupational Health and Radiation Control, Texas State Department of Health, Austin, Texas.

[2] Copies of earlier reports are available on request from the Texas State Department of Health.

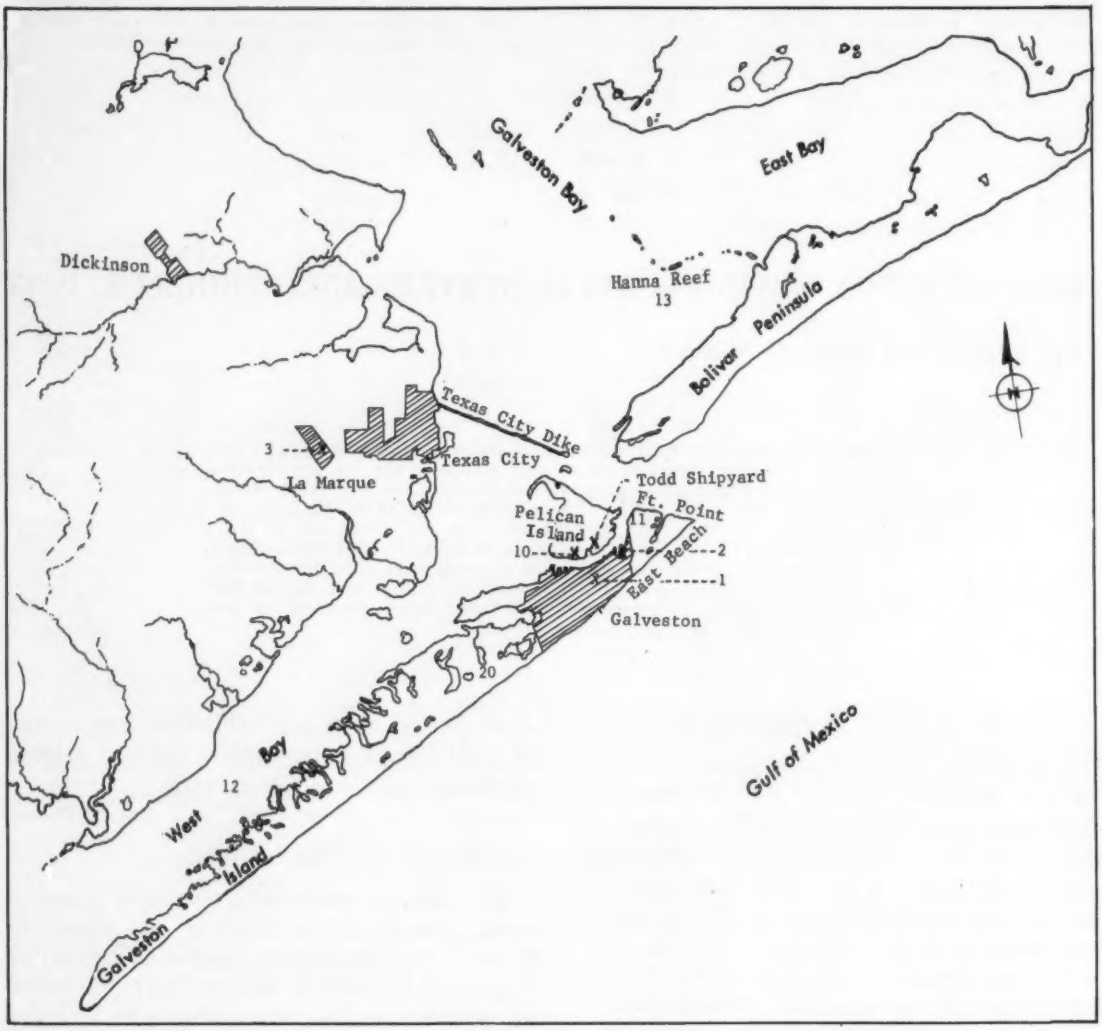

Figure 1. Sampling station locations

Four liters of raw milk were collected monthly from a dairy located on Galveston Island on a reimbursable basis.

All samples collected were analyzed by the Texas State Health Department Laboratory in Austin, Texas. The types of analysis performed are listed in table 2.

The analytical results of environmental samples collected in the Galveston vicinity are presented below.

Air radioactivity

Air samples were collected with a high-volume sampler located on the roof of the Galveston City Hall. Gross beta radioactivity in these air samples is listed in table 3, and monthly averages are shown graphically in figure 2.

Wide fluctuations of radioactivity in air occurred during the first year's operation as reported in the previous report. This was

Table 1. Schedule of sample collection

Station number	Location	Sample type	Sample collected during report period
1	Galveston City Hall	Air	Yes
2	Ferry Landing	Air	No
3	Galveston County Health Department Building, La Marque	Air	No
1	Galveston	Rain	Yes
10	U.S. Naval Reserve Pier	Seawater	Yes
11	U.S. Corps of Engineers Pier	Seawater	Yes
10	Galveston Channel	Silt	Yes
11	Galveston Channel	Silt	Yes
12	West Bay	Silt	No
13	Hanna Reef, East Bay	Oysters	No
20	Shaper's Dairy, Galveston	Milk	Yes

Table 2. Analytical and sampling activities of Galveston 1965 program

Type of radioactivity analysis	Type of sample
Gross beta	All except milk
Gross alpha	All except milk and air
Gamma scan	All except air
Chemical separations: carbonate and basic sulfides	Seawater
Strontium-89 and strontium-90	Milk

Table 3. Radioactivity in air at Galveston City Hall

Date filter removed, 1965	Gross beta (pCi/m³)	Date filter removed, 1965	Gross beta (pCi/m³)
March 1	0.2	June 7	0.8
3	0.2	9	0.6
5	0.3	11	0.5
8	0.5	14	0.5
10	0.5	16	0.1
12	0.3	18	0.3
15	0.3	21	0.3
17	0.4	23	0.8
19	0.3	25	0.2
24	0.4	28	0.2
26	0.1	30	0.1
29	0.2	July 2	0.2
30	0.1	6	0.2
April 2	0.1	9	0.1
5	0.2	12	0.1
7	0.4	14	0.1
9	0.3	16	0.1
12	0.3	19	0.1
14	0.3	21	0.2
16	0.4	23	0.2
19	0.3	26	0.2
21	0.5	28	0.1
23	0.3	30	0.1
26	0.3	Aug 2	0.1
May 3	0.4	4	0.1
7	0.3	6	NS
10	0.3	9	NS
14	0.3	11	NS
17	0.3	13	NS
19	0.4	16	0.1
?	0.1	18	0.1
24	0.3	20	0.1
26	0.3	23	0.1

?, Date uncertain.
NS, no sample.

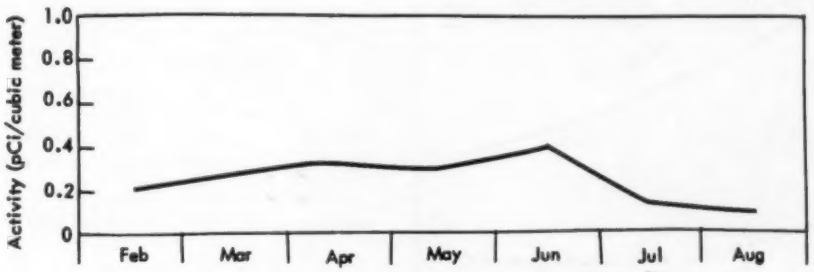

Figure 2. Gross beta activity in air, Station 1, Galveston City Hall, February–August 1965

shown to be the result of fallout from nuclear weapons testing. However, during the time period covered in this report, only those fluctuations associated with normal background were observed.

Seawater radioactivity

The high dissolved solids content of seawater makes the standard gross beta and gross alpha determinations impractical from an analytical standpoint; therefore chemical fractionation of samples has been performed. The carbonate and basic sulfides fractions have been used in this study as indicators of seawater contamination. The activity of the carbonate fraction is indicative of alkaline earths content. Strontium and radium are part of this chemical family.

The activity of the basic sulfides fraction is indicative of the transitional elements and the rare earths. These include cobalt, zinc, iron, nickel, ruthenium, yttrium, zirconium, and cerium. Interference due to sodium solids, cesium, and potassium–40 activity is eliminated by these two processes.

Seawater samples were collected from two locations during this report period. Results of the analyses are given in tables 4 and 5. There was little, if any, change in the levels of radioactivity found during previous surveillance operation. Most samples were below the limit of detectability (1.0 pCi/liter). The highest concentration in the carbonate fraction was 2 pCi/liter, and basic sulfides fraction, 12 pCi/liter. These low levels can be attributed to natural background.

Milk radioactivity

The concentration of various radionuclides in the raw milk samples is listed in table 6 and shown graphically in figure 3. It should be noted that the short half-life radionuclides, iodine–131 and barium–140, were not detected in any

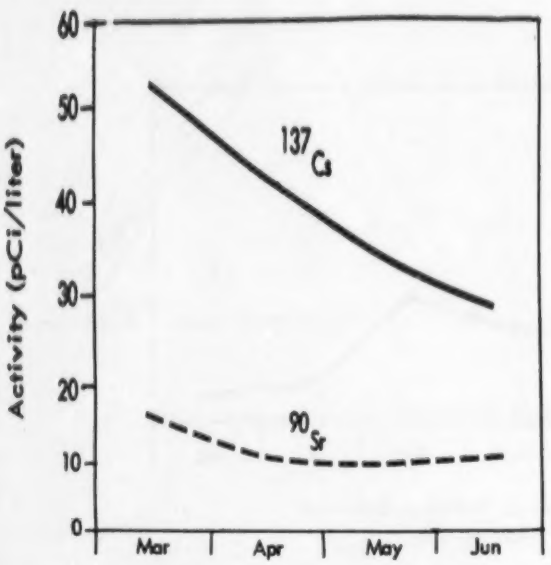

Figure 3. Radioactivity in milk, Station 20 Galveston, March–June 1965

of the samples. The longer half-life radionuclides, strontium–90 and cesium–137, are shown to be decreasing during the report period. This pattern of fluctuating strontium–90 and cesium–137 with the absence of iodine–131 and barium–140 corresponds with that found all over the United States by the Public Health Service through its Pasteurized Milk Surveillance Network. Therefore, these radionuclide concentrations in milk from Galveston can be attributed entirely to fallout from nuclear weapons testing.

Table 4. Radioactivity in seawater, Station 10

Date collected 1965	Suspended solids		Dissolved solids				Gamma scan (pCi/liter)
	Gross alpha (pCi/liter)	Gross beta (pCi/liter)	Gross alpha (pCi/liter)		Gross beta (pCi/liter)		
			C [a]	BS [b]	C [a]	BS [b]	
Feb 23..	NA	NA	<1	<1	<1	4	[c]
March 16..	NA	NA	<1	<1	1	3	[c]
23..	NA	NA	<1	<1	1	3	[c]
30..	<1	<1	<1	<1	1	6	[c]
April 6..	<1	2	<1	<1	1	12	[c]
13..	<1	<1	<1	<1	1	4	[c]
20..	<1	2	<1	<1	2	1	[c]
May 4..	<1	2	<1	<1	1	2	[c]
11..	<1	1	<1	<1	2	2	[c]
18..	<1	6	<1	1	2	1	[c]
June 1..	1	3	1	<1	2	1	[c]
15..	<1	2	1	<1	2	3	[c]
30..	<1	4	<1	<1	1	3	[c]

[a] C, carbonate
[b] BS, basic sulfide
[c] Below quantitative levels except potassium-40.
NA, no analysis

Table 5. Radioactivity in seawater, Station 11

Date collected 1965	Suspended solids		Dissolved solids				Gamma scan (pCi/liter)
	Gross alpha (pCi/liter)	Gross beta (pCi/liter)	Gross alpha (pCi/liter)		Gross beta (pCi/liter)		
			C [a]	BS [b]	C [a]	BS [b]	
Feb 23..	NA	NA	<1	<1	1	2	[c]
March 16..	NA	NA	<1	<1	<1	2	[c]
23..	<1	<1	<1	1	<1	5	[c]
30..	NA	NA	<1	1	1	2	[c]
April 6..	<1	2	<1	<1	1	9	[c]
13..	<1	2	<1	<1	1	2	[c]
20..	1	1	1	1	2	2	[c]
May 4..	<1	2	<1	<1	1	2	[c]
11..	1	2	<1	<1	2	2	[c]
18..	<1	5	<1	<1	1	5	[c]
June 1..	<1	2	<2	<1	2	2	[c]
15..	<1	2	1	<1	2	3	[c]
29..	<1	1	<1	<1	2	1	[c]

[a] C, carbonate
[b] BS, basic sulfide
[c] Below quantitative levels except potassium-40.
NA, no analysis

Discussion

The results reported herein are almost entirely free of large fluctuations. This was due not only to the absence of significant contamination from the Nuclear Ship Savannah operations, but also because no atmospheric nuclear

Table 6. Radioactivity in silt, stations 10 and 11 [a]

Station number and date	Gross beta (pCi/g)	Gross alpha (pCi/g)
Station 10		
2/23/65	23	6
8/30/65	30	12
Station 11		
2/23/65	18	6
8/30/65	20	5

[a] Results of gamma scans gave no peaks other than those attributable to naturally occurring radionuclides.

Table 7. Radioactivity in milk, Station 20

Date collected 1965	Radionuclide concentrations, pCi/liter			
	Iodine-131	Barium-140	Cesium-137	Strontium-90
March 10	[a] <10	[a] <10	50	16
16	<10	<10	60	18
23	<10	<10	45	18
30	<10	<10	55	15
April 6	<10	<10	50	15
13	<10	<10	45	13
20	<10	<10	35	9
May 4	<10	<10	40	9
11	<10	<10	30	10
18	<10	<10	35	12
June 2	<10	<10	35	13
15	<10	<10	30	11
30	<10	<10	25	8

[a] Minimum detectable level 10 pCi/liter (2σ analytical error)

weapons testing occurred during this report period. With the exception of the milk samples, almost all results were shown to be below the detectable limits or just above that limit. As was discussed earlier, the milk radioactivity trends followed closely the nationwide trend as shown by the Public Health Service.

The absence of significant findings during this report period is indicative of the ability of ships using nuclear power to operate without undue risk to the public.

Conclusions

As the result of the 1965 operation of the Galveston Environmental Surveillance Program, it has been shown that no detectable radioactive contamination occurred in the Galveston-Pelican Island area due to the operations of the Nuclear Ship Savannah. The low levels of radioactivity detected in the various environmental samples are attributed to naturally occurring radionuclides and long-life mixed fission products from nuclear weapons testing.

REFERENCE

(1) PORTER, C. R., R. J. AUGUSTINE, J. M. MATUSEK, JR., and M. W. CARTER. Procedures for determination of stable elements and radionuclides in environmental samples. Public Health Service Publication No. 999-RH-10 (January 1965).

Section I. Milk and Food

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Efforts are being made by both Federal and State agencies to monitor the intake of various radionuclides in the total diet on a continuing basis. Although the total diet is the most direct measure of intake of radionuclides, indicator foods may be used to estimate dietary intake where specific dietary data are not available. As fresh milk is consumed by a large segment of the U.S. population and contains most of the biologically significant radionuclides from nuclear test debris which appear in the diet, it is the single food item most often used as an indicator of the population's intake of radionuclides. Moreover, it is the major source of dietary intake of short-lived radionuclides. In the absence of specific dietary information, it is possible to approximate the total daily dietary intake of selected radionuclides as being equivalent to the intake represented by the consumption of 1 liter of milk. More direct estimates of dietary intake of radionuclides than those furnished by indicator foods can be obtained by analysis of the total diet or representative principal food items or groups combined with appropriate consumption data.

The Federal Radiation Council has developed Radiation Protection Guides (RPG's) for controlling normal peacetime operations, assuming continuous exposure from intake by the population at large (*1,2*). The RPG's do not and cannot establish a line which is safe on one side and unsafe on the other; they do provide an indication of when there is a need to initiate careful evaluation of exposure (*3*). Additional guidelines are provided by the International Commission on Radiological Protection (*4, 5*).

Data from selected National, International, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross section of routine sampling programs which may be considered of a continuing nature.

REFERENCES

(*1*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 1. Superintendent of Documents, U.S. Printing Office, Washington, D.C. 20402 (May 13, 1960).
(*2*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1960).
(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, protective action guides for strontium–89, strontium–90, and cesium–137, Report No. 7. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1965).
(*4*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendation of the International Commission on Radiological Protection, Report No. 2. Pergamon Press (1959).
(*5*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendation of the International Commission on Radiological Protection, Report No. 6. Pergamon Press (1965).

NATIONAL AND INTERNATIONAL MILK SURVEILLANCE

As part of continuing efforts to quantitatively monitor man's exposure to radionuclides, various National and International organizations routinely monitor radionuclide levels in milk. In addition to those programs reported below, *Radiological Health Data and Reports* coverage includes:

Program	Period reported	Last presented
Radiostrontium in milk, HASL	April–June 1965	March 1966
United Kingdom milk	January 1961–April 1962	October 1962

1. Pasteurized Milk Network January 1966

Division of Radiological Health and Division of Environmental Engineering and Food Protection, PHS

The Public Health Service's Pasteurized Milk Network (PMN) was designated to provide nationwide surveillance of radionuclide concentrations in milk through sampling from major milk production and consumption areas. The present network of 63 sampling stations (figure 1) provides data on milk in every State. In addition, milk is sampled in the Canal Zone and Puerto Rico. The most recent description of the sampling and analytical procedures employed by the PMN appeared in the December 1965 *Radiological Health Data.*

Figure 1. Pasteurized Milk Network sampling stations

Table 1. Average concentrations of stable elements and radionuclides in pasteurized milk for the fourth quarter 1965 and January 1966 [a]

Sampling location		Calcium (g/liter)		Strontium-89 (pCi/liter)		Strontium-90 (pCi/liter)		Cesium-137 (pCi/liter)	
		Fourth quarter 1965	January 1966	Fourth quarter 1965	January 1966	Fourth quarter 1965	January 1966	Fourth quarter 1965	January 1966
Ala:	Montgomery	1.18	1.24	<5	<5	14	12	30	25
Alaska:	Palmer	1.30	1.25	<5	<5	15	13	55	45
Ariz:	Phoenix	1.25	1.25	<5	<5	4	4	15	15
Ark:	Little Rock	1.20	1.21	<5	<5	27	25	30	40
Calif:	Sacramento	1.27	1.30	<5	<5	4	5	15	20
	San Francisco	1.29	1.27	<5	<5	4	4	15	15
C.Z:	Cristobal	1.13	1.14	<5	<5	5	4	35	25
Colo:	Denver	1.28	1.28	<5	<5	12	12	25	25
Conn:	Hartford	1.12	1.13	<5	<5	12	11	40	40
Del:	Wilmington	1.15	1.21	<5	<5	14	13	35	35
D.C:	Washington	1.16	1.18	<5	<5	13	13	25	30
Fla:	Tampa	1.18	1.18	<5	<5	14	11	135	110
Ga:	Atlanta	1.17	1.19	<5	<5	19	19	45	40
Hawaii:	Honolulu	1.16	1.19	<5	<5	6	5	40	35
Idaho:	Idaho Falls	1.28	1.29	<5	<5	13	13	45	40
Ill:	Chicago	1.14	1.12	<5	<5	11	10	35	35
Ind:	Indianapolis	1.17	1.19	<5	<5	12	12	25	35
Iowa:	Des Moines	1.26	1.23	<5	<5	14	14	20	25
Kans:	Wichita	1.27	1.31	<5	<5	13	14	20	20
Ky:	Louisville	1.16	1.18	<5	<5	17	16	20	25
La:	New Orleans	1.22	1.26	<5	<5	30	28	40	40
Maine:	Portland	1.14	1.14	<5	<5	17	14	165	65
Md:	Baltimore	1.17	1.15	<5	<5	16	13	25	25
Mass:	Boston	1.15	1.16	<5	<5	16	14	60	60
Mich:	Detroit	1.12	1.13	<5	<5	11	10	30	35
	Grand Rapids	1.16	1.22	<5	<5	14	13	45	45
Minn:	Minneapolis	1.26	1.29	<5	<5	22	20	40	45
Miss:	Jackson	1.24	1.26	<5	<5	25	22	25	20
Mo:	Kansas City	1.22	1.23	<5	<5	16	16	20	20
	St. Louis	1.27	1.17	<5	<5	18	15	20	20
Mont:	Helena	1.31	1.28	<5	<5	15	14	45	60
Nebr:	Omaha	1.22	1.25	<5	<5	16	15	25	20
Nev:	Las Vegas	1.27	1.25	<5	<5	5	6	25	20
N.H:	Manchester	1.14	1.17	<5	<5	18	17	70	75
N.J:	Trenton	1.14	1.15	<5	<5	11	10	30	40
N.Mex:	Albuquerque	1.23	1.30	<5	<5	6	7	20	15
N.Y:	Buffalo	1.10	1.15	<5	<5	11	9	40	40
	New York	1.11	1.10	<5	<5	14	13	40	45
	Syracuse	1.10	1.14	<5	<5	12	10	35	35
N.C:	Charlotte	1.20	1.22	<5	<5	25	19	30	30
N.Dak:	Minot	1.27	1.28	<5	<5	30	32	40	45
Ohio:	Cincinnati	1.15	1.16	<5	<5	13	12	20	25
	Cleveland	1.14	1.16	<5	<5	13	13	25	35
Okla:	Oklahoma City	1.17	1.16	<5	<5	14	12	20	20
Ore:	Portland	1.27	1.28	<5	<5	12	13	40	40
Pa:	Philadelphia	1.12	1.16	<5	<5	12	11	30	35
	Pittsburgh	1.13	1.18	<5	<5	17	16	40	45
P.R:	San Juan	1.11	1.17	<5	<5	9	8	30	20
R.I:	Providence	1.14	1.17	<5	<5	15	13	45	45
S.C:	Charleston	1.19	1.20	<5	<5	25	22	55	45
S.Dak:	Rapid City	1.23	1.13	<5	<5	21	19	45	45
Tenn:	Chattanooga	1.25	1.22	<5	<5	22	20	30	25
	Memphis	1.18	1.19	<5	<5	18	17	20	20
Tex:	Austin	1.17	1.17	<5	<5	6	5	10	15
	Dallas	1.17	1.20	<5	<5	12	14	20	20
Utah:	Salt Lake City	1.38	1.39	<5	<5	12	12	40	35
Vt:	Burlington	1.12	1.18	<5	<5	14	15	50	55
Va:	Norfolk	1.18	1.15	<5	<5	16	16	25	25
Wash:	Seattle	1.30	1.27	<5	<5	16	15	45	40
	Spokane	1.31	1.36	<5	<5	16	14	45	35
W.Va:	Charleston	1.16	1.14	<5	<5	16	14	20	25
Wis:	Milwaukee	1.20	1.20	<5	<5	12	10	40	40
Wyo:	Laramie	1.29	1.20	<5	<5	16	15	45	30
Network average		1.20	1.26	<5	<5	14.6	13.5	35	35

[a] Results of iodine-131 and barium-140 analyses below detectable levels.

Table 2. Frequency distribution, strontium-90 concentrations in milk at Pasteurized Milk Network stations, January 1965, August–December 1965, and January 1966

Strontium-90 (pCi/liter)	Number of stations						
	1965						1966
	Jan	Aug	Sept	Oct	Nov	Dec	Jan
Under 10	6	10	11	8	9	9	10
10–19	32	41	44	46	43	43	46
20–29	19	11	7	7	9	11	6
30–39	4	1	1	2	2	0	1
40–49	1	0	0	0	0	0	0
50–59	1	0	0	0	0	0	0

Table 3. Frequency distribution, cesium-137 concentrations in milk at Pasteurized Milk Network stations, January 1965, August–December 1965, and January 1966

Cesium-137 (pCi/liter)	Number of stations						
	1965						1966
	Jan	Aug	Sept	Oct	Nov	Dec	Jan
Under 50	11	45	50	54	57	51	57
50–99	38	16	12	8	5	11	5
100–149	12	1	0	0	1	1	1
150–199	2	1	1	1	0	0	0

The results for January 1966 and fourth quarter of 1965 are presented in table 1. The average monthly radionuclide concentrations are based on results obtained from samples collected weekly. If radionuclide values were below minimum detectable concentrations (*1*), averages were calculated using one-half the minimum detectable value; however, for iodine–131 and barium–140, zero was used for averaging purposes when concentrations were below minimum detectable levels.

For comparative purposes, distributions of strontium–90 and cesium–137 are presented in tables 2 and 3 for August 1965 through January 1966, and January 1965. The average strontium–90 concentrations in pasteurized milk from selected cities are presented in figure 2.

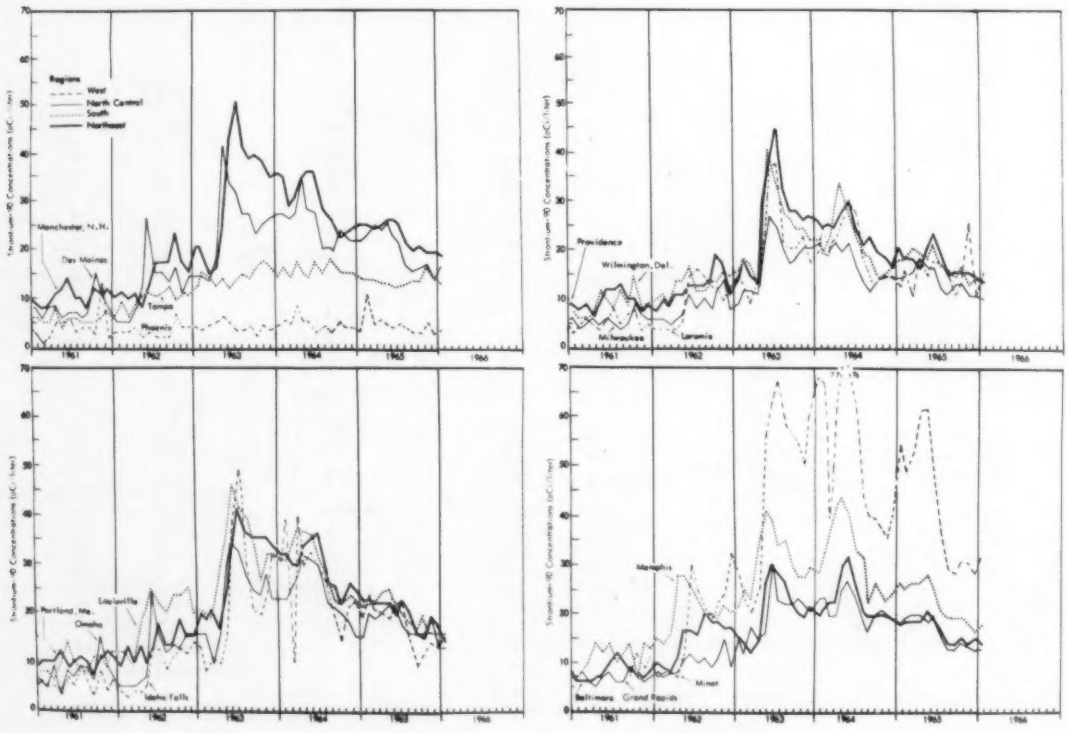

Figure 2. Strontium–90 concentrations in pasteurized milk, 1961—January 1966

2. Canadian Milk Network January 1966[1]

Radiation Protection Division
Department of National Health
and Welfare, Ottawa, Canada

Since November 1955, the Radiation Protection Division of the Department of National Health and Welfare has been monitoring milk for radionuclide concentrations. Powdered milk was originally sampled, but liquid whole milk has been sampled since January 1963. At present, 16 milk sampling stations (figure 3) are in operation. Their locations coincide with air and precipitation sampling stations.

Milk samples are collected three times a week from selected dairies and are combined into weekly composites. The contribution of each dairy to the composite sample is directly proportional to the liquid volume of sales. Weekly spot check analyses are made for iodine–131, and monthly composites are analyzed for strontium–90, cesium–137, and stable calcium and potassium. The analytical procedures were outlined in the December 1965 issue of *Radiological Health Data* (*2*).

The January 1966 monthly average strontium–90, cesium–137, and stable calcium and potassium concentrations in Canadian whole milk are presented in table 4. Iodine–131 and strontium–89 concentrations were below minimum detectable levels.

[1] Prepared from February 1966 monthly report, "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

Table 4. Stable elements and radionuclides in Canadian whole milk, January 1966

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary	1.09	1.4	15.9	55
Edmonton	1.04	1.4	18.3	81
Ft. William	1.12	1.7	30.8	79
Fredericton	1.11	1.6	27.8	71
Halifax	1.03	1.5	21.1	68
Montreal	1.10	1.6	20.8	48
Ottawa	1.12	1.6	15.1	41
Quebec	1.06	1.6	27.2	86
Regina	1.03	1.4	15.6	32
St. John's, Nfld	1.05	1.5	28.5	89
Saskatoon	1.12	1.6	17.9	39
Sault Ste. Marie	1.11	1.6	26.7	75
Toronto	1.12	1.6	8.7	35
Vancouver	1.18	1.7	24.0	96
Windsor	1.11	1.6	8.8	27
Winnipeg	1.02	1.7	18.6	63
Average	1.09	1.6	20.4	62

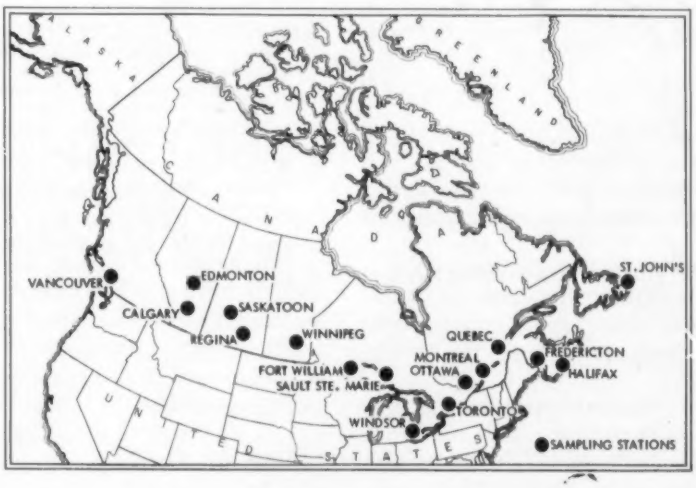

Figure 3. Canadian milk sampling stations

3. Pan American Milk Sampling Program January 1966

Pan American Health Organization and Public Health Service

The Pan American Health Organization (PAHO), in collaboration with the Public Health Service (PHS), furnishes assistance to health agencies in the American Republics in developing national radiological health programs.

Under a joint agreement between both agencies, air and milk sampling activities are conducted by a number of PAHO member countries (figure 4). Results of the milk sampling program are presented below. Further information on the sampling and analytical procedures employed was presented in the December 1965 issue of *Radiological Health Data* (*3*).

Figure 4. Pan American Milk Network sampling locations

Table 5 presents stable calcium and potassium, strontium–90, strontium–89, and cesium–137 monthly average concentrations. The monthly average iodine–131 and barium–140 concentrations in milk were less than 10 pCi/liter.

Table 5. Stable element and radionuclide concentrations in PAHO milk January 1966

Sampling station	Calcium (g/liter)	Potassium (g/liter)	Strontium-89 (pCi/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Canal Zone:					
Cristobal	1.14	1.4	<5	4	25
Jamaica:					
Kingston	1.11	1.34	<5	11	115
Mandeville	NS	NS	NS	NS	NS
Montego Bay	NS	NS	NS	NS	NS
Puerto Rico:					
San Juan	1.17	1.5	<5	8	20
Venezuela:					
Caracas	1.16	1.37	<5	3	15

NS, no sample collected.

REFERENCES

(*1*) PUBLIC HEALTH SERVICE. Milk surveillance, Pasteurized Milk Network, August 1965. Division of Radiological Health and Division of Environmental Engineering and Food Protection. Rad Health Data 6:677–681 (December 1965).

(*2*) RADIATION PROTECTION DIVISION, DEPARTMENT OF NATIONAL HEALTH AND WELFARE, OTTAWA, CANADA. Canadian Milk Network, August 1965. Rad Health Data 6:685–686 (December 1965).

(*3*) PAN AMERICAN HEALTH ORGANIZATION and PUBLIC HEALTH SERVICE. Pan American Milk Sampling Program, August 1965. Rad Health Data 6:687 (December 1965).

STATE MILK SURVEILLANCE ACTIVITIES

Considerable progress has been made by the State health departments in initiating or expanding environmental surveillance activities in radiological health. Many of the States have progressed to the level of comprehensive environmental surveillance programs and self-sustaining radiological health laboratories.

The continuing efforts of State health departments in the analysis and monitoring of radionuclides in milk complement Federal milk surveillance activities. State milk surveillance activities are continually undergoing developmental changes at this time. The results presented herein, while not inclusive, are representative of current surveillance activities directed at the use of milk as an indicator of dietary intake of radioactivity.

In addition to the networks presented herein, other State networks previously covered in *Radiological Health Data and Reports* include:

State milk network	Period reported	Last presented
California	July–September 1965	March 1966
Colorado	October–December 1964	April 1965
Florida	July–December 1965	March 1966
Oklahoma	August–December 1965	March 1966
Oregon	July–September 1965	March 1966
Pennsylvania	July–September 1965	February 1966
Texas	April–December 1965	March 1966
Washington	July–September 1965	March 1966

1. Connecticut Milk Network October–December and Annual Summary 1965

Connecticut State Department of Health

The Connecticut State Department of Health has been monitoring pasteurized milk for strontium–89 and strontium–90 since April 1960. In May 1962, the program was expanded to include the determination of gamma-emitting radionuclides in milk.

The sampling program is flexible in nature, providing for sampling in five areas of the State (figure 1). At the present time, a monthly sample representative of milk sold in the central area of the State is collected and analyzed for strontium–89, strontium–90, and gamma emitters. Concentrations of iodine–131 are determined as an indication of the presence of radioactivity of recent origin.

Strontium–89 and strontium–90 are determined by chemical separation. Iodine–131 and other gamma emitters are determined by gamma-scintillation spectroscopy.

The monthly average concentrations of strontium–89, strontium–90, iodine–131, and cesium–137 in Connecticut pasteurized milk are presented in table 1. These results are presented graphically in figure 2. A summary of 1965 monthly average concentration is presented in table 2.

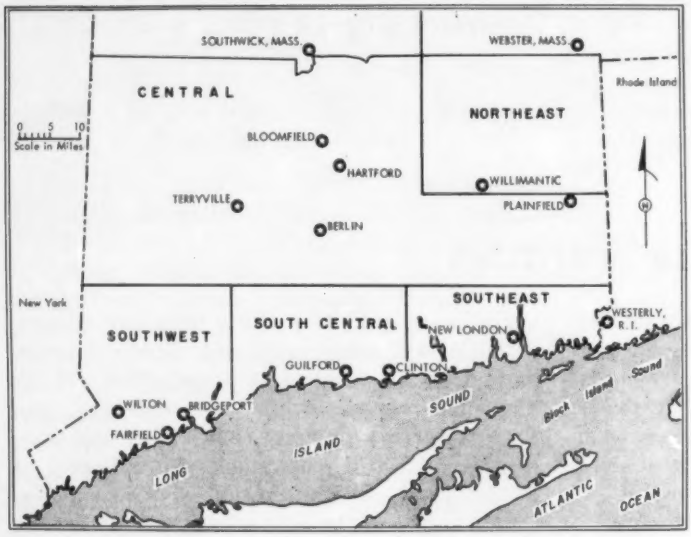

Figure 1. Connecticut pasteurized milk sampling areas

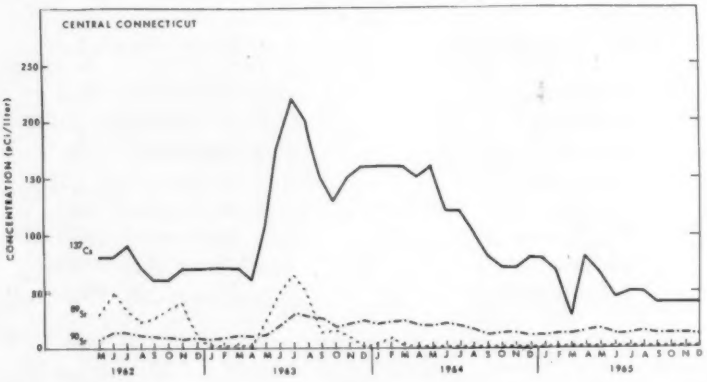

Figure 2. Radionuclide concentrations in Connecticut pasteurized milk, 1962–December 1965

Table 1. Radionuclide concentrations in central Connecticut milk, October–December 1965

Month 1965	Concentration, pCi/liter			
	Strontium-89	Strontium-90	Iodine-131	Cesium-137
October	ND	13	<10	40
November	ND	13	<10	40
December	ND	12	<10	40

ND, below detectable levels.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
April 1960–December 1962	May 1963
Annual Summary 1963	September 1964
Annual Summary 1964	May 1965
January-March 1965	August 1965
April–September 1965	February 1966

Table 2. Monthly average radionuclide concentrations in Connecticut milk, 1965

Month 1965	Concentration, pCi/liter			
	Strontium-89	Strontium-90	Iodine-131	Cesium-137
January	ND	13	<10	80
February	ND	15	<10	70
March	ND	15	<10	30
April	ND	15	<10	80
May	ND	16	<10	70
June	ND	13	<10	40
July	ND	13	<10	50
August	ND	14	<10	50
September	ND	13	<10	40
October	ND	13	<10	40
November	ND	13	<10	40
December	ND	12	<10	40

ND, below detectable levels.

2. Indiana Milk Network October–December and Annual Summary 1965

Bureau of Environmental Sanitation
Indiana State Board of Health

The Indiana State Board of Health began sampling pasteurized milk for radionuclide analysis in September 1961. The State was geographically divided into five major milksheds: northeast, northwest, central, southeast, and southwest (figure 3). One large dairy within each milkshed was assumed to be representative for sampling purposes.

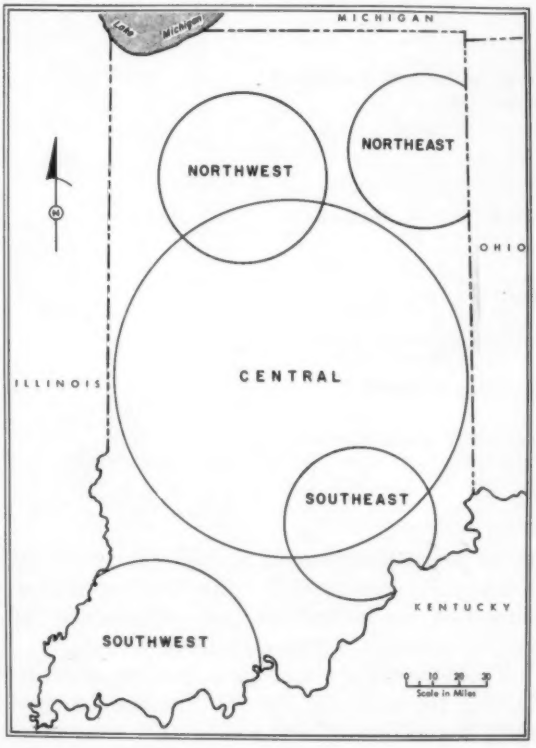

Figure 3. Indiana pasteurized milk sampling areas

The milk samples are analyzed for strontium–89, strontium–90, cesium–137, iodine–131, and barium–140. Strontium–89 and strontium–90 analyses are performed monthly while cesium–137, iodine–131 and barium–140 analyses are performed weekly. When iodine–131 concentrations exceed 100 pCi/liter, the sampling frequency is increased. Since August 1963, because of the continued low concentrations of short-lived radionuclides, the sampling frequency has been once a month for the northeast, southeast, and southwest milksheds.

Strontium–89 and strontium–90 concentrations in milk samples are determined by ion exchange separation (*1*, *2*) while cesium–137, iodine–131, and barium–140 are determined by gamma-scintillation spectrometry (*3*).

The monthly radionuclide concentrations in Indiana pasteurized milk are presented by station in table 3 for October through December 1965. The monthly concentrations of iodine–131 and barium–140 remained below limits of detectability.

The monthly network average concentrations of strontium–89, strontium–90, and cesium–137 are presented graphically in figure 4. A summary of 1965 monthly average concentration is presented in table 4.

Table 4. Monthly average radionuclide concentrations in Indiana milk, 1965

Month 1965	Concentration, pCi/liter			
	Strontium-89	Strontium-90	Iodine-131	Cesium-137
January	0	16	0	65
February	0	15	0	65
March	0	16	0	70
April	0	15	0	70
May	0	14	20	45
June	15	11	20	45
July	0	12	0	30
August	0	15	0	30
September	0	13	0	25
October	0	12	0	30
November	0	13	0	25
December	0	13	0	25

Table 3. Radionuclides in Indiana milk, October–December 1965

Sampling location	Calcium, g/liter			Potassium-40, pCi/liter			Strontium-90, pCi/liter			Cesium-137, pCi/liter		
	Oct	Nov	Dec	Oct	Nov	Dec	Oct	Nov	Dec	Oct	Nov	Dec
Northeast	1.22	1.13	1.14	1,330	1,310	1,380	11	13	11	30	25	30
Southeast	1.17	1.17	1.16	1,440	1,400	1,370	13	14	16	30	25	30
Central	1.20	1.15	1.12	1,350	1,400	1,400	9	12	12	20	25	25
Southwest	1.20	1.13	1.19	1,370	1,320	1,400	14	14	15	35	20	20
Northwest	1.17	1.15	1.12	1,350	1,370	1,380	14	13	13	30	30	30
Average	1.19	1.15	1.15	1,370	1,360	1,390	12	13	13	30	25	25

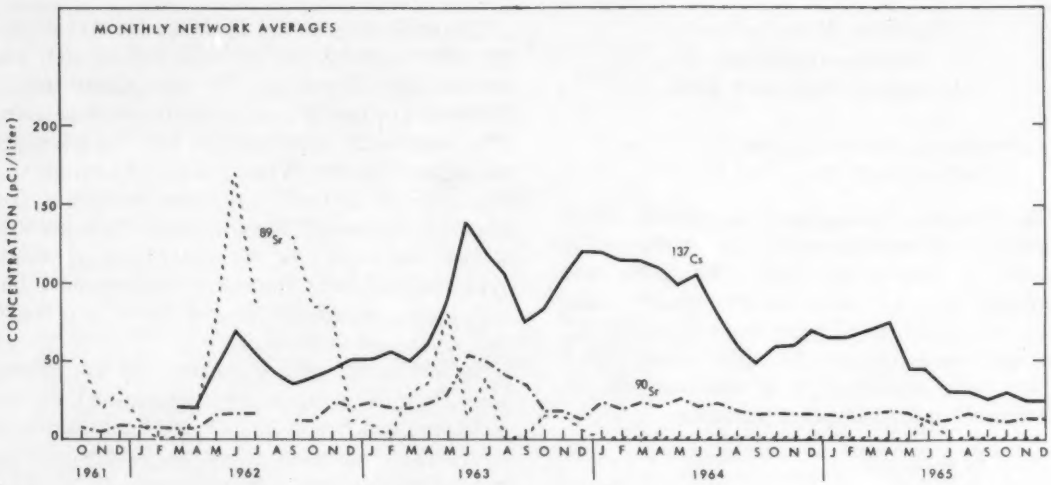
MONTHLY NETWORK AVERAGES
CONCENTRATION (pCi/liter)
200
150
100
50
0
89Sr
137Cs
90Sr
O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1961
1962
1963
1964
1965

Figure 4. Radionuclide concentrations in Indiana pasteurized milk, 1961–December 1965

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
Annual Summary 1961–1964	May 1965
January–March 1965	August 1965
April–June 1965	November 1965
July–September 1965	February 1966

3. Michigan Milk Network October-December and Annual Summary 1965

Division of Occupational Health
Michigan Department of Health

The Michigan Department of Health began sampling pasteurized milk for radionuclide analyses in November 1964. Under this program, weekly pasteurized milk samples are collected in the seven major milk producing areas in the State: Charlevoix, Detroit, Grand Rapids, Lansing, Marquette, Monroe, and Saginaw (see figure 5). Milkshed samples are composites of dairies in proportion to sales volumes.

Strontium–90 concentrations are determined by an ion exchange method (*4*). Potassium–40, iodine–131, cesium–137, and barium–lanthanum–140 concentrations are determined by gamma scintillation spectrometry (*4*).

Table 5 presents the monthly average radionuclide concentrations in Michigan pasteurized milk. Strontium–90 and cesium–137 concentrations are presented graphically in figure 6 to show general trends. A summary of 1965 monthly average concentrations is presented in table 6.

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
November 1962–December 1964	September 1965
January–June 1965	November 1965
July–September 1965	February 1966

Figure 5. Michigan pasteurized milk network sampling locations

Table 5. Radionuclides in Michigan pasteurized milk, October–December 1965

Station	Month	Concentration, pCi/liter				
		Potassium-40	Strontium-90	Iodine-131	Cesium-137	Barium-lanthanum-140
Charlevoix	October	1,360	19	<14	37	<4
	November	1,340	17	<14	33	<4
	December	1,320	24	<14	38	<4
Detroit	October	1,310	12	<14	21	<4
	November	1,310	13	<14	21	<4
	December	1,350	13	<14	21	<4
Grand Rapids	October	1,320	17	<14	30	<4
	November	1,330	18	<14	33	<4
	December	1,360	15	<14	34	<4
Lansing	October	1,300	15	<14	26	<4
	November	1,310	14	<14	24	<4
	December	1,340	13	<14	26	<4
Marquette	October	1,300	29	<14	57	<4
	November	1,330	27	<14	53	<4
	December	1,390	29	<14	55	<4
Monroe	October	1,320	11	<14	17	<4
	November	1,330	10	<14	18	<4
	December	1,320	12	<14	20	<4
Saginaw	October	1,360	12	<14	23	<4
	November	1,320	12	<14	23	<4
	December	1,390	10	<14	22	<4
Average	October	1,320	16	<14	30	<4
	November	1,320	16	<14	29	<4
	December	1,350	17	<14	31	<4

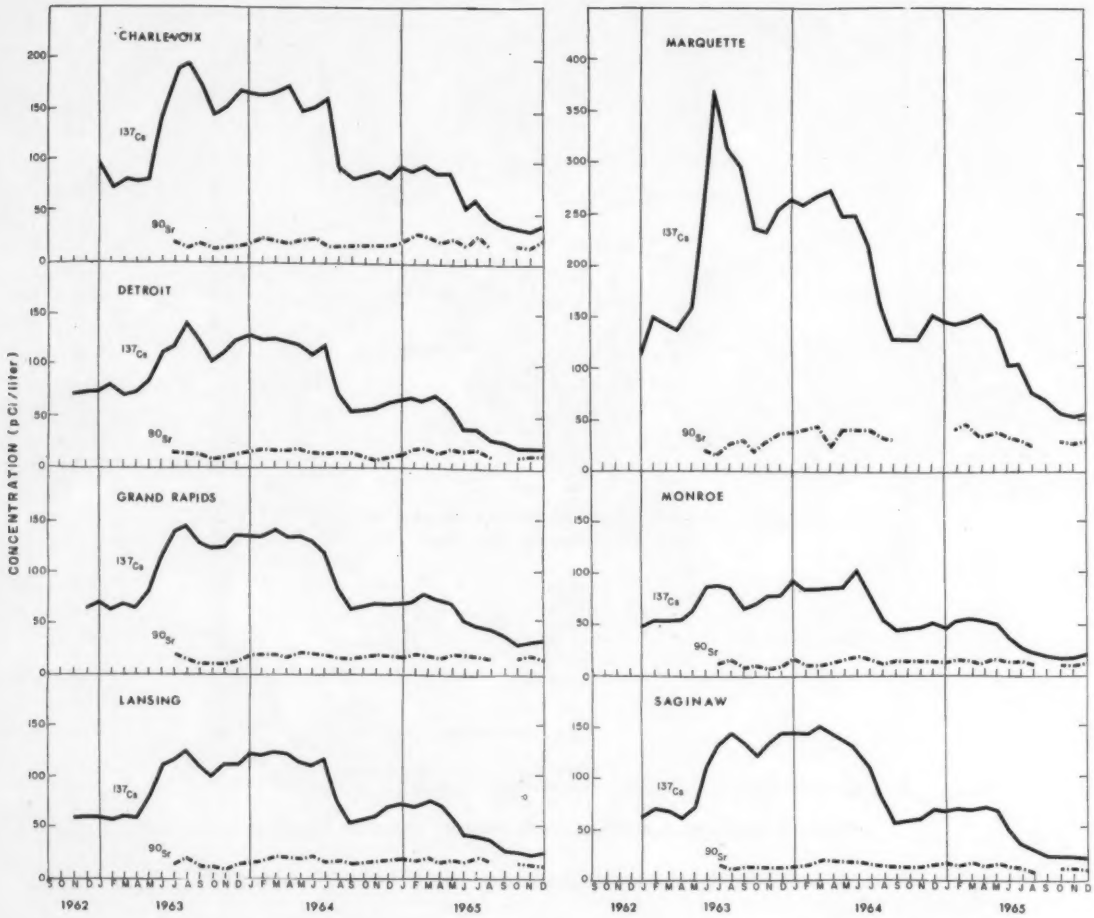

Figure 6. Radionuclide concentrations in Michigan pasteurized milk, 1962–1965

Table 6. Monthly average radionuclide concentrations in Michigan milk, 1965

Month 1965	Concentration, pCi/liter				
	Potassium-40	Strontium-90	Iodine-131	Cesium-137	Barium-lanthanum-40
Janauary	1,360	18	<14	80	<4
February	1,360	23	<14	81	<4
March	1,335	24	<14	83	<4
April	1,330	20	<14	82	<4
May	1,360	22	<14	76	<4
June	1,320	20	18	55	<4
July	1,340	18	<14	48	<4
August	1,330	14	<14	39	<4
September	1,320	NA	<14	33	<4
October	1,320	16	<14	30	<4
November	1,320	16	<14	29	<4
December	1,350	17	<14	31	<4

NA, no analysis performed

4. Minnesota Milk Network July-December and Annual Summary 1965

Division of Environmental Health
Minnesota Department of Health

In September 1958, the Minnesota Department of Health initiated a pasteurized milk network to monitor strontium–90 concentrations. Presently, monthly samples are collected from eight sampling locations in milksheds, geographically the same as the Minnesota health districts (figure 7), for strontium–90, iodine–131, and cesium–137 analyses. One-liter samples of processed grade A fluid milk are collected at bottling machines in pasteurization plants. The samples are customarily collected in the cities where the Minnesota Health District offices are located. However, it is sometimes convenient to collect at other locations. Such samples are considered representative of the district concerned.

Strontium–90 concentrations are determined radiochemically, while iodine–131 and cesium–137 concentrations are determined by gamma scintillation spectrometry. The analytical procedures are presented in the semiannual report of the Minnesota Department of Health and Rural Cooperative Power Association (*5*).

Strontium–90 (table 6), iodine–131 (table 7), and cesium–137 (table 8) concentrations in milk are given for July through December 1965. The strontium–90, cesium–137, and

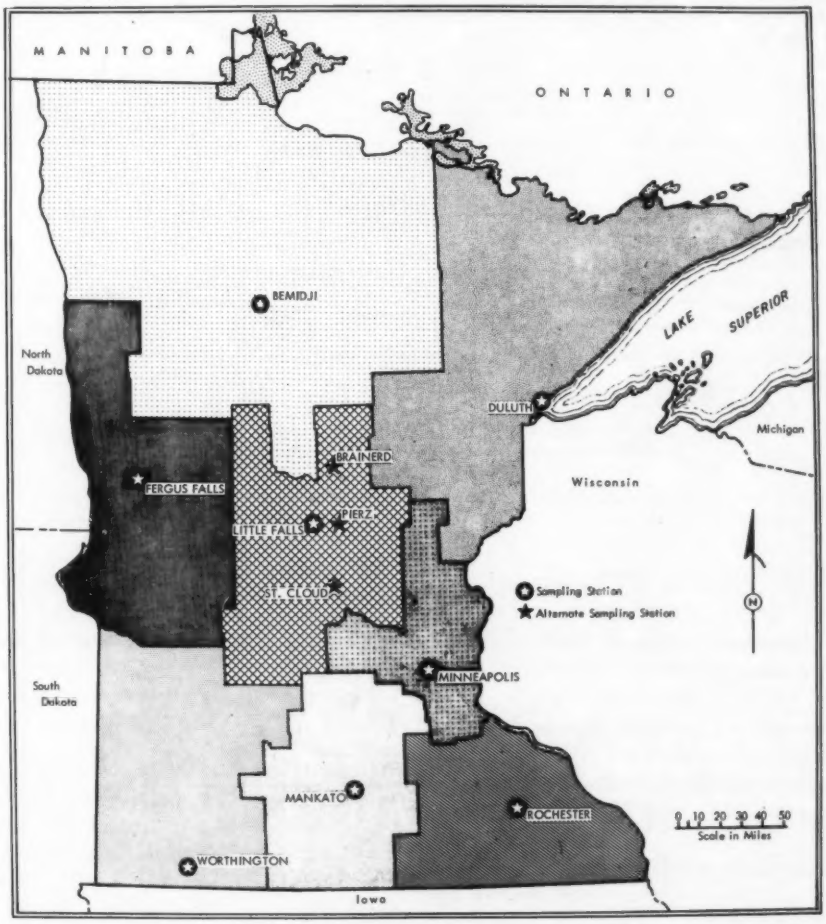

Figure 7. Minnesota milk sampling locations

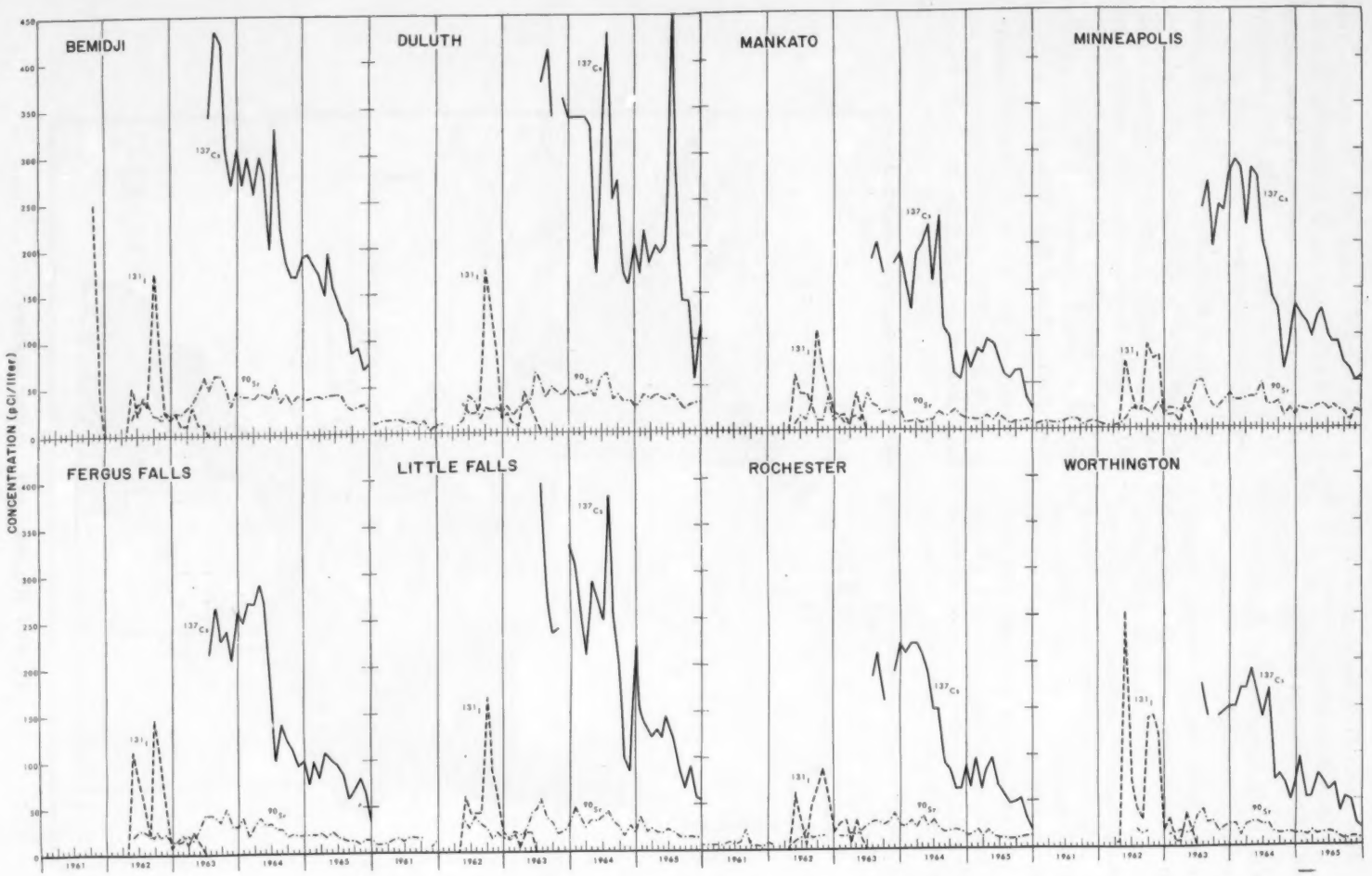

Figure 8. Radionuclide concentrations in Minnesota milk, 1961–1965

Table 6. Strontium-90 concentrations in Minnesota milk, July–December 1965

Sampling location	Strontium-90, pCi/liter						
	July	Aug	Sept	Oct	Nov	Dec	Average July–Dec 1965
Bemidji	41	29	26	29	31	24	30
Mankato	12	7	9	8	11	8	9
Rochester	12	10	11	12	13	13	12
Duluth	40	33	25	28	31	32	31
Worthington	14	9	7	10	10	8	10
Minneapolis	23	19	17	7	18	17	17
Fergus Falls	15	13	13	10	17	14	14
Little Falls	21	15	15	16	14	16	16
Average	22	17	15	15	18	16	17

Table 8. Cesium-137 concentrations in Minnesota milk, July–December 1965

Sampling location	Cesium-137, pCi/liter						
	July	Aug	Sept	Oct	Nov	Dec	Average July–Dec 1965
Bemidji	130	120	86	92	70	92	98
Mankato	59	56	63	64	34	23	50
Rochester	57	48	50	53	32	20	43
Duluth	450	190	140	140	57	110	180
Worthington	66	37	52	49	24	20	41
Minneapolis	91	92	70	73	50	55	72
Fergus Falls	85	60	67	81	66	36	66
Little Falls	120	87	68	91	57	54	80
Average	134	86	74	80	49	51	79

Table 7. Iodine-131 concentrations in Minnesota milk, July–December 1965

Collection point	Collection date [a]	Iodine-131 (pCi/liter)
Worthington	7/1/65	15
Little Falls	7/5/65	10
Worthington	8/2/65	15
Rochester	8/2/65	10
Rochester	10/4/65	12

[a] The remaining samples analyzed July through December 1965, showed less than 10 pCi/liter of iodine-131.

iodine–131 concentrations in Minnesota pasteurized milk are presented graphically by milkshed in figure 8 for the period 1962–December 1965. A summary of 1965 monthly average concentrations is presented in table 9.

Table 9. Monthly average radionuclide concentrations in Minnesota milk, 1965

Month 1965	Concentration, pCi/liter	
	Strontium-90	Cesium-137
January	26	115
February	22	125
March	23	110
April	23	120
May	22	125
June	22	110
July	22	134
August	17	86
September	15	74
October	15	80
November	18	49
December	16	51

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
November 1962–December 1964	September 1965
January–June 1965	January 1966

5. New York Milk Network July-December and Annual Summary 1965

Division of Environmental Health Services
Department of Health, State of New York

Pasteurized milk samples collected routinely from six cities (figure 9) are analyzed for strontium–89, strontium–90, iodine–131, and barium-lanthanum–140 by the New York State Department of Health. At Buffalo, Newburgh, and Syracuse milk samples are collected from processing plants on a daily basis and composited weekly for radiochemical analyses. At Massena, samples are composited biweekly, while in New York, a milk sample representing the total milk supply for one day is obtained and composited weekly for analysis. The Albany sample, taken at a marketing point, is analyzed daily for iodine–131 and other gamma-emitting radionuclides before being composited into a weekly sample. In the event that any sample contains iodine–131 concentrations exceeding 100 pCi/liter, increased surveillance is undertaken.

Gamma-emitting radionuclides in milk are

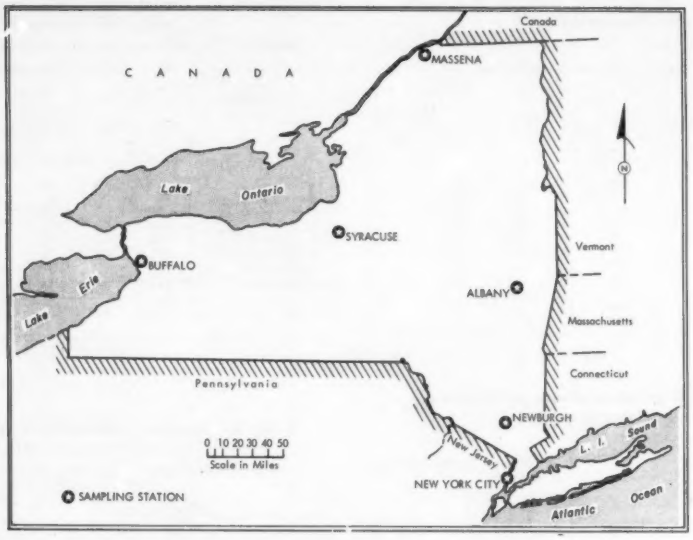

Figure 9. New York milk sampling stations

determined by scintillation spectrometry and the application of a matrix method of analysis (*7*) to the resultant spectral data.

The analytical procedure for determining strontium–89 and strontium–90 concentrations employs an ion exchange system similar to that developed by Porter and Kahn (*2*).

The monthly average radionuclide concentrations of strontium–89 (table 10), strontium–90 (table 11), iodine–131 (table 12), and cesium–137 (table 13) are shown for July through December 1965. Cesium–137 and iodine–131 concentrations since September 1961 are presented graphically in figure 10. A summary of 1965 monthly average concentrations is presented in table 14.

Table 10. Strontium-89 concentrations in New York milk, July–December 1965

Sampling location	Strontium-89, pCi/liter					
	July	Aug	Sept	Oct	Nov	Dec
Albany	4	<3	<3	<3	<3	<3
Ashford	NS	5	NS	NS	<3	<3
Bedford	9	<3	<3	<4	<3	NA
Buffalo	4	4	<3	<3	<3	<3
Clarktown	NS	<3	NS	<3	NS	NA
East Otto	NS	<3	NS	NS	<3	<3
Massena	5	7	<3	<3	<3	<3
Middleburg	7	4	<3	<3	<3	<3
Mount Pleasant	<3	<3	<3	NA	<3	<3
Newburgh	4	<3	<3	<3	<3	<3
New York city	8	3	<3	<3	<3	<3
Oyster Bay	<3	8	4	<3	<3	NA
Syracuse	<3	<3	<3	<3	<3	<3
Yaphank	NS	NS	NS	NS	NS	NS
Yorkshire	NS	<3	NS	NS	NS	<3
Yorktown	<3	<3	<3	<3	<3	<3
Average	<5	<4	<3	<3	<3	<3

NA, no analysis
NS, no sample collected

Table 11. Strontium-90 concentrations in New York milk, July–December 1965

Sampling location	Strontium-90, pCi/liter					
	July	Aug	Sept	Oct	Nov	Dec
Albany	12	10	13	12	7	7
Ashford	NS	22	NS	NS	16	10
Bedford	22	21	19	27	14	NA
Buffalo	11	9	10	9	6	7
Clarktown	NS	6	NS	11	NS	NA
East Otto	NS	20	NS	NS	11	8
Massena	11	13	13	10	19	16
Middleburg	17	15	11	12	10	11
Mount Pleasant	12	10	7	NA	10	7
Newburgh	14	14	15	12	12	11
New York city	21	18	19	16	13	12
Oyster Bay	17	6	6	11	10	NA
Syracuse	17	8	7	10	7	7
Yaphank	NS	NS	NS	NS	NS	NS
Yorkshire	NS	22	NS	NS	NS	15
Yorktown	26	16	18	18	9	19
Average	16	14	13	13	11	12

NA, no analysis
NS, no sample collected

Table 12. Iodine-131 concentrations in New York milk, July–December 1965

Sampling location	Iodine-131, pCi/liter					
	July	Aug	Sept	Oct	Nov	Dec
Albany	<20	<20	<20	<20	<20	<20
Ashford	NS	<20	NS	NS	NA	NA
Bedford	<20	<20	<20	<20	<20	<20
Buffalo	23	<20	<20	<20	<20	<20
Clarktown	NS	<20	NS	<20	NS	<20
East Otto	NS	<20	NS	NS	NA	NA
Massena	<20	<20	<20	<20	<20	<20
Middleburg	<20	<20	<20	<20	<20	<20
Mount Pleasant	<20	<20	<20	<20	<20	<20
Newburgh	<20	<20	<20	<20	<20	<20
New York	<20	<20	<20	<20	<20	<20
Oyster Bay	<20	<20	<20	<20	<20	<20
Syracuse	<20	<20	<20	<20	<20	<20
Yaphank	NS	NS	NS	NS	NS	NS
Yorkshire	NS	<20	NS	NS	NS	NA
Yorktown	<20	<20	<20	<20	<20	<20
Average	<21	<20	<20	<20	<20	< 20

NA, no analysis
NS, no sample collected

Table 13. Cesium-137 concentrations in New York milk, July–December 1965

Sampling location	Cesium-137, pCi/liter					
	July	Aug	Sept	Oct	Nov	Dec
Albany	32	28	23	22	26	27
Ashford	NS	31	NS	NS	NA	NA
Bedford	51	50	29	26	39	27
Buffalo	31	19	18	23	25	30
Clarktown	NS	24	NS	20	NS	31
East Otto	NS	39	NS	NS	NA	NA
Massena	71	69	47	44	46	52
Middleburg	33	25	19	23	26	27
Mount Pleasant	35	35	29	26	27	27
Newburgh	45	41	36	30	24	28
New York	48	44	31	32	31	35
Oyster Bay	75	67	56	53	52	48
Syracuse	29	24	24	20	23	21
Yaphank	NS	NS	NS	NS	NS	NS
Yorkshire	NS	31	NS	NS	NS	NS
Yorktown	52	50	28	54	31	41
Average	46	39	31	31	32	33

NA, no analysis
NS, no sample collected

Table 14. Monthly average radionuclide concentrations in New York milk, 1965

Month 1965	Concentration, pCi/liter			
	Strontium-89	Strontium-90	Iodine-131	Cesium-137
January	<3	14	<20	74
February	<3	16	<20	72
March	<3	17	<20	71
April	<3	16	<20	72
May	<3	16	<20	71
June	<3	16	<20	62
July	<5	16	<21	46
August	<4	14	<20	29
September	<3	13	<20	31
October	<3	13	<20	31
November	<3	11	<20	32
December	<3	12	<20	33

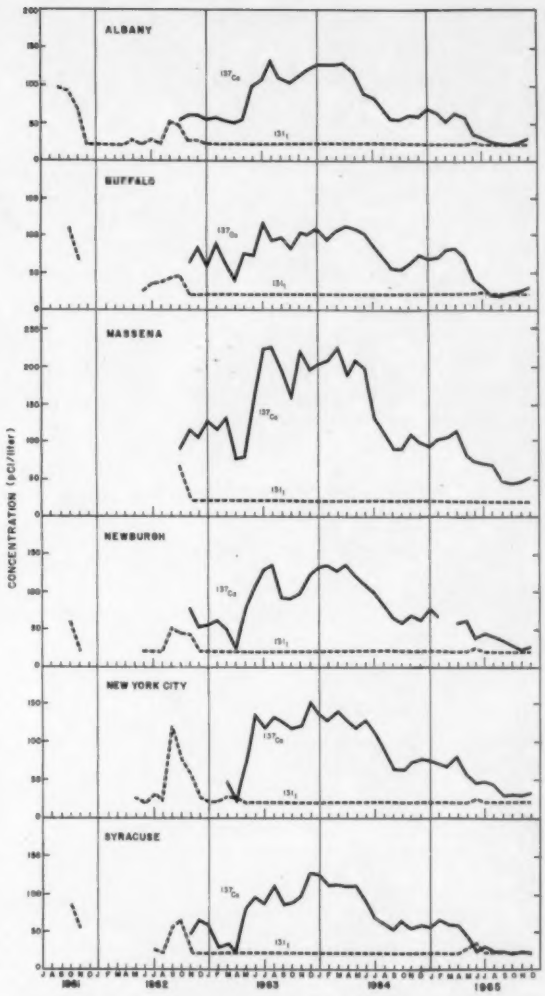

Figure 10. Radionuclide concentrations in New York milk 1961–1965

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
July–September 1964	April 1965
October–December 1964	May 1965
January–March 1965	June 1965
April–June 1965	January 1966

6. Pennsylvania Milk Network October–December 1965

Bureau of Environmental Health
Pennsylvania Department of Health

Samples of pasteurized milk are routinely collected from 10 major milk consumption areas throughout Pennsylvania (figure 11). Two samples per week are collected in Philadelphia and Pittsburgh, while weekly composite samples are collected from the other eight stations. At each sampling location subsamples are collected from the major dairies supplying the area and are composited in proportion to the amount of milk processed by each dairy. This composite is then sent to the Radiation Laboratory of the Division of Occupational Health in Harrisburg where the weekly samples are combined for monthly analyses. Strontium–90 analyses have been carried out since April 1963.

The chemical separation technique for strontium–90 is essentially an ion exchange method described by Porter and Kahn (*2*).

The monthly average potassum–40, strontium–90, iodine–131, and cesium–137 concentrations in pasteurized milk are given in table 15. For comparative purposes, strontium–90, iodine–131, and cesium–137 concentrations are presented graphically in figure 12. A summary of 1965 annual average concentrations is presented in table 16.

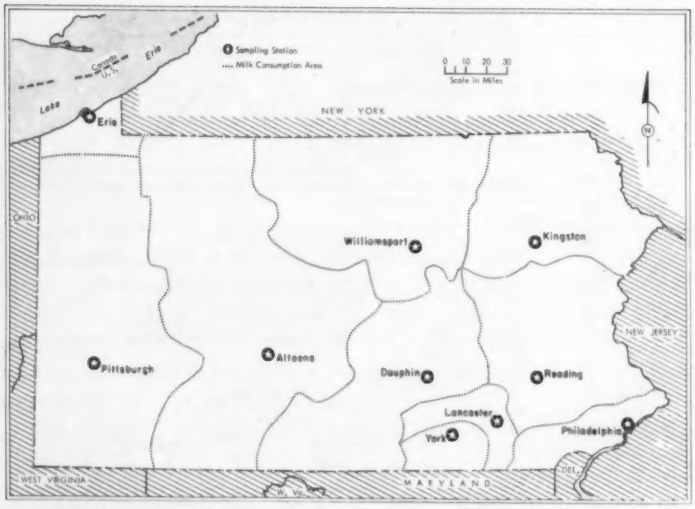

Figure 11. Pennsylvania pasteurized milk network sampling locations

Table 15. Potassium-40, strontium-90, and cesium-137 concentrations in Pennsylvania milk October–December 1965 [a]

Sampling location	Concentrations, pCi/liter								
	Potassium-40			Strontium-90			Cesium-137		
	Oct	Nov	Dec	Oct	Nov	Dec	Oct	Nov	Dec
Altoona	1,040	1,090	1,070	16	15	18	58	64	64
Dauphin	1,060	1,050	1,210	12	10	17	62	51	65
Erie	1,050	1,070	950	16	12	25	80	74	74
Kingston	1,040	1,050	1,010	19	24	19	64	65	68
Lancaster	1,120	1,000	1,090	14	14	14	65	53	61
Philadelphia	950	980	1,000	13	18	17	52	55	50
Pittsburgh	990	970	940	15	25	15	60	61	67
Reading	960	980	1,060	12	8	10	74	43	58
Williamsport	1,090	1,050	900	20	12	21	65	68	56
York	1,000	1,100	1,050	11	12	13	65	66	66
Average	1,030	1,035	1,030	14.8	15.0	16.9	64	60	62

[a] Iodine-131 concentrations for this period were less than the minimum detectable level of 10 pCi/liter.

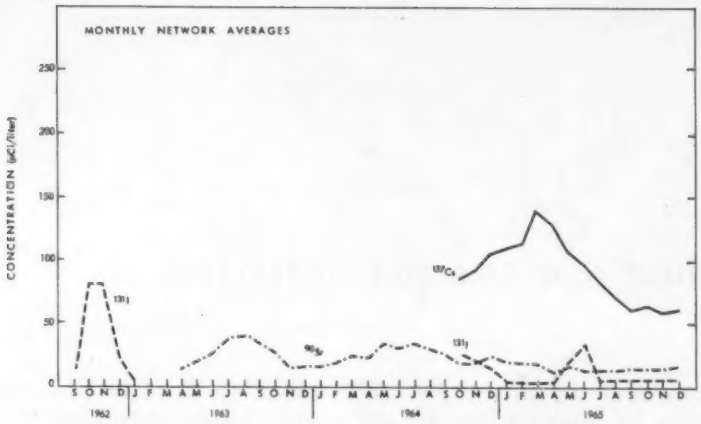

Figure 12. Radionuclide concentrations in Pennsylvania pasteurized milk, 1962–December 1965

Table 16. Monthly average radionuclide concentrations in Pennsylvania milk, 1965

Month 1965	Concentration, pCi/liter			
	Potassium-40	Strontium-90	Iodine-131	Cesium-137
January	1,070	23	<10	112
February	1,090	20	<10	116
March	1,150	20	<10	139
April	1,120	17	<10	129
May	1,070	19	22	107
June	1,050	15	31	95
July	1,020	13	<10	82
August	1,030	13	<10	71
September	1,020	15	<10	61
October	1,030	15	<10	64
November	1,035	15	<10	60
December	1,030	17	<10	62

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
August–September 1964	February 1965
Annual 1964	June 1965
January–March 1965	September 1965
April–June 1965	November 1965
July–September 1965	February 1966

REFERENCES

(*1*) PORTER, C., D. CAHILL, R. SCHNEIDER, P. ROBBINS, W. E. PERRY, and B. KAHN. Determination of strontium–90 in milk by an ion-exchange method. Anal Chem 33:1306–1308 (September 1961).

(*2*) PORTER, C., and B. KAHN. Improved determinations of strontium–90 in milk by an ion-exchange method. Anal Chem 36:676–678 (March 1964).

(*3*) BUREAU OF ENVIRONMENTAL SANITATION, INDIANA STATE BOARD OF HEALTH. Indiana Milk Network, April-June 1965. Rad Health Data 6:612–614 (November 1965).

(*4*) MICHIGAN DEPARTMENT OF HEALTH. Michigan milk network, November 1962–December 1964. Rad Health Data 6:487–492 (September 1965).

(*5*) MINNESOTA DEPARTMENT OF HEALTH AND RURAL COOPERATIVE POWER ASSOCIATION. Survey of environmental radioactivity, January-June 1965. COO–615–617 (August 1965).

(*6*) DIVISION OF ENVIRONMENTAL HEALTH, MINNESOTA DEPARTMENT OF HEALTH. State milk surveillance activites, Minnesota milk network, January-June 1965. Rad Health Data & Reports 7: 21–22 (January 1966).

(*7*) KAHN, B., G. K. MURTHY, C. PORTER, G. R. HAGEE, G. J. KARCHES, and A. S. GOLDIN. Rapid methods for estimating fission product concentrations in milk. PHS Publication No. 999–R–2 (March 1963). Single copies available on request from Public Inquiries Branch, PHS, U.S. Department of Health, Education, and Welfare, Washington, D.C. 20201.

FOOD AND DIET SURVEILLANCE ACTIVITIES

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuous basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in routine operation and reported periodically include: (1) the Public Health Service's Institutional Total Diet Sampling Network, (2) the Atomic Energy Commission's Tri-City Diet Study, (3) the Food and Drug Administration's Teenage Diet Study, (4) the State of California's Diet Study, and (5), the State of Connecticut's Standard Diet Study. While not based on probability sampling, these networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* are listed below:

Program	Period reported	Last presented
Tri-City Diet	May–July 1965	March 1966
Teenage Diet	February–November 1964	July 1965
California Diet	January–April 1965	March 1966
Connecticut Standard Diet	March 1963–December 1964	July 1965

1. Radionuclides in Institutional Diet Samples July–September 1965

Division of Radiological Health
Public Health Service

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiation surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. This program is administered by the Division of Radiological Health with the assistance of the Division of Environmental Engineering and Food Protection (*1*).

The program was designed to estimate the dietary intake of radionuclides in a selected population group ranging from children to young adults of school age. Initially, the program was conducted at eight institutions; as of January 1965, its scope had increased to boarding schools or institutions in 50 municipalities distributed as shown in figure 1. These institutions ranged from financially well-to-do boarding schools to orphanages with severe economic limitations.

Experience with sampling school children of various ages led to a modification in the choice of institutions sampled as of the July 1965 sampling. Previous results showed that the daily intake of teenage girls and children from 9 to 12 years of age was comparable, while teenage boys consumed 20 percent more food per day

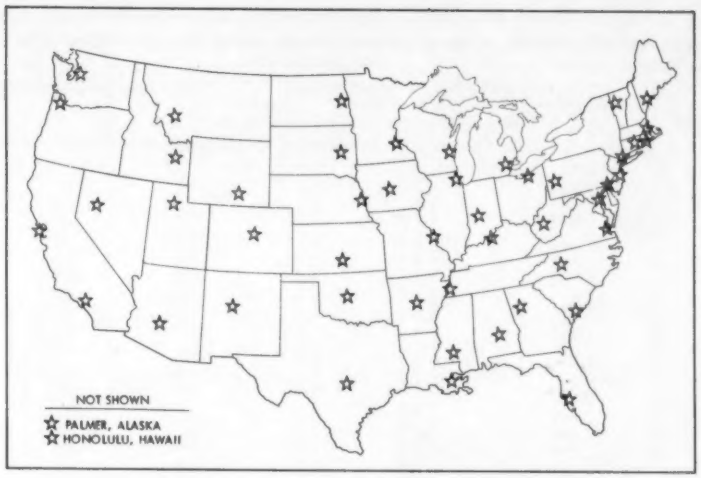

Figure 1. Institutional diet sampling locations

(*1*, *2*). Consequently, estimates for teenage boys and/or girls can be calculated on the basis of levels consumed by children.

In general, the sampling procedure is the same at each institution. Each sample supplied by each institution monthly represents the edible portion of the diet for a full 7-day week (21 meals, plus soft drinks, candy bars, or other in-between snacks), obtained by duplicating the meals of a different individual each day. Drinking water is not included in the samples but is sampled periodically. Each daily sample is kept frozen until the end of the collection period, and is then packed in dry ice and shipped by air express to either the Southwestern Radiological Health Laboratory, Las Vegas, Nevada; the Southeastern Radiological Health Laboratory, Montgomery, Alabama; or the Northeastern Radiological Health Laboratory, Winchester, Massachusetts. A detailed description of sampling and analytical procedures is presented elsewhere (*3*).

Results

Table 1 presents the analytical results for institutional diet samples collected from July through September 1965, for children 9 to 12 years of age. Stable elements are reported in g/kg of diet, and radionuclide concentrations are expressed as pCi/kg of diet. The 20 stations reported consist of two stations in each of nine geographic areas of the country, one station in Hawaii and one station in Alaska.

Dietary intakes, presented in table 2, were obtained by multiplying the food consumption rate in kg/day times the concentration values given in table 1. The reported radionuclide concentrations of these samples are corrected for radioactive decay to the midpoint of the sample collection period where applicable.

Certain of the radionuclide concentration results have been reported as being "less than" (<) a specified value. For purposes of data computations to obtain dietary intakes, "less than" 10 pCi/kg values for iodine–131 and barium–140 were interpreted as zero and "less than" 5 pCi/kg of strontium–89 as 2.5 pCi/kg.

The average dietary intake during this period was 1.83 kg/day and was comparable to the network average of 1.90 kg/day observed from 1961 through 1964 (*4*).

While strontium–89 dietary intake remained below detectable levels, the strontium–90 dietary intake during this period remained fairly constant at approximately 23 pCi/day. These results fall within Range II as defined by the Federal Radiation Council (5), indicating that quantitative surveillance and routine control are recommended.

Table 1. Stable elements and radionuclide concentrations in institutional diets of children, July–September 1965

Location of institution	Month (1965)	Stable element concentrations, g/kg of diet		Radionuclide concentrations, pCi/kg of diet			
		Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137	Radium-226
Alaska: Palmer	July	0.6	1.2	<5	17	55	0.4
	Aug	0.8	1.4	<5	25	235	0.2
	Sept [a]	0.3	0.8	<5	5	40	0.1
Ariz: Phoenix	July	0.5	1.0	<5	6	35	NA
	Aug	0.9	0.8	<5	2	15	0.2
	Sept	0.7	1.5	<5	13	50	0.4
Ark: Little Rock	July	0.6	1.4	<5	26	40	NA
	Aug	0.5	1.2	<5	17	25	NA
	Sept	0.6	1.3	<5	24	30	NA
Calif: Los Angeles	July	0.8	1.8	<5	9	30	0.6
	Aug	0.6	1.6	<5	7	25	0.4
	Sept	0.7	1.5	<5	6	40	0.4
Colo: Denver	July	0.7	1.2	<5	11	55	0.5
	Aug	0.7	1.3	<5	9	30	0.4
	Sept	0.6	1.5	<5	8	35	0.3
Del: Wilmington	July	0.8	1.6	5	14	50	0.6
	Aug	0.7	1.8	<5	10	30	0.7
	Sept	0.7	1.6	<5	13	35	0.7
Fla: Tampa	July	0.8	1.7	<5	12	130	NA
	Aug	0.7	1.8	<5	10	105	NA
	Sept	0.8	1.7	<5	14	135	NA
Hawaii: Honolulu	July	0.5	1.0	<5	9	35	0.6
	Aug	0.5	1.3	<5	9	45	NA
	Sept	NS	NS	NS	NS	NS	NS
Idaho: Idaho Falls	July	1.0	1.5	20	34	65	0.7
	Aug	1.0	1.4	<5	12	65	0.6
	Sept	1.0	1.6	<5	9	40	0.5
Ill: Chicago	July	0.8	1.3	<5	9	50	0.4
	Aug	0.8	1.6	<5	9	30	0.5
	Sept	0.7	1.6	<5	9	40	0.4
Ky: Louisville	July	0.5	1.0	<5	12	35	NA
	Aug	0.6	1.6	<5	12	30	NA
	Sept	0.6	1.3	<5	19	30	NA
La: New Orleans	July	0.8	1.6	<5	24	45	NA
	Aug	0.6	1.6	<5	17	40	NA
	Sept	0.6	1.5	<5	22	40	NA
Mass: Boston	July	0.5	1.4	<5	10	40	0.5
	Aug	0.6	1.4	<5	12	50	0.6
	Sept	0.8	1.7	<5	10	35	0.7
Mo: St. Louis	July	0.7	1.5	<5	14	30	0.8
	Aug	0.7	1.7	<5	13	25	0.7
	Sept	0.8	1.6	<5	11	45	0.7
Ohio: Cleveland	July	0.7	1.6	<5	12	40	0.5
	Aug	0.6	1.8	<5	8	40	0.7
	Sept	0.6	1.7	<5	9	50	0.6
Pa: Pittsburgh	July	0.6	1.6	5	10	35	0.8
	Aug	0.5	1.4	5	12	40	0.6
	Sept	0.6	1.4	<5	8	40	0.8
S.C: Charleston	July	0.6	1.3	<5	15	40	NA
	Aug	0.7	1.1	<5	20	55	NA
	Sept	0.7	1.6	<5	18	55	NA
S. Dak: Sioux Falls	July	0.9	1.8	10	17	75	0.6
	Aug	0.8	1.6	<5	16	50	0.7
	Sept	0.6	1.6	<5	12	60	0.5
Tex: Austin	July	0.5	1.0	<5	8	20	NA
	Aug	0.4	1.1	<5	8	25	NA
	Sept	0.7	2.0	<5	12	30	NA
Vt: Burlington	July	0.9	1.4	5	13	65	0.7
	Aug	1.0	2.0	<5	20	60	0.7
	Sept	0.6	1.6	<5	10	40	0.6
Wash: Seattle	July	0.7	1.7	<5	20	80	0.4
	Aug	0.8	2.0	<5	23	60	0.2
	Sept	0.7	2.0	<5	15	60	0.4
Institutional average	July	0.7	1.4	<5	14	50	0.4
	Aug	0.7	1.5	<5	13	50	0.3
	Sept	0.7	1.6	<5	12	45	0.4

[a] Does not contain milk portion of diet (lost in shipment).
NA, no analysis
NS, no sample

Table 2. Intake of stable elements and radionuclides in institutional total diet for children (9–12 years of age) July–September 1965

Location of institution	Month (1965)	Total weight (kg/day)	Stable elements, g/day		Radionuclide intakes, pCi/day			
			Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137	Radium-226
Alaska: Palmer	July	1.94	1.2	2.3	5	33	105	0.8
	Aug	1.64	1.3	2.3	5	41	385	0.3
	Sept	[a] 0.94	0.3	0.8	5	5	40	0.1
Ariz: Phoenix	July	1.64	0.8	1.6	5	10	55	NA
	Aug	1.54	1.4	1.2	5	3	25	0.3
	Sept	1.85	1.3	2.8	5	24	95	0.7
Ark: Little Rock	July	1.98	1.2	2.8	5	51	80	NA
	Aug	1.58	0.8	1.9	5	27	40	NA
	Sept	1.30	0.8	1.7	5	31	40	NA
Calif: Los Angeles	July	1.79	1.4	3.2	5	16	55	1.1
	Aug	1.70	1.0	2.7	5	12	40	0.7
	Sept	1.94	1.4	2.9	5	12	80	0.8
Colo: Denver	July	2.49	1.7	3.0	5	27	135	1.2
	Aug	2.40	1.7	3.1	5	22	70	1.0
	Sept	2.39	1.4	3.6	5	19	85	0.7
Del: Wilmington	July	1.77	1.4	2.8	10	25	90	1.1
	Aug	2.03	1.4	3.7	5	20	60	1.4
	Sept	2.11	1.5	3.4	5	27	75	1.5
Fla: Tampa	July	2.05	1.6	3.5	5	25	265	NA
	Aug	2.12	1.5	3.8	5	21	225	NA
	Sept	1.87	1.5	3.2	5	26	250	NA
Hawaii: Honolulu	July	[b] 1.72	0.9	1.7	5	15	60	1.0
	Aug	1.89	0.9	2.5	5	17	85	NA
	Sept	NS	NS	NS	NS	NS	NS	NS
Idaho: Idaho Falls	July	[c] 2.03	2.0	3.0	40	69	130	1.4
	Aug	[b] 1.98	2.0	2.8	5	24	130	1.2
	Sept	[b] 2.32	2.3	3.7	5	21	95	1.2
Ill: Chicago	July	1.57	1.3	2.0	5	14	80	0.6
	Aug	1.57	1.3	2.5	5	14	45	0.8
	Sept	1.86	1.3	3.0	5	17	75	0.7
Ky: Louisville	July	1.74	0.9	1.7	5	21	60	NA
	Aug	1.72	1.0	2.8	5	21	50	NA
	Sept	1.41	0.8	1.8	5	27	40	NA
La: New Orleans	July	2.24	1.8	3.6	5	54	100	NA
	Aug	2.49	1.5	4.0	5	42	100	NA
	Sept	[c] 1.56	0.9	2.3	5	34	60	NA
Mass: Boston	July	1.97	1.0	2.8	5	20	80	1.0
	Aug	2.32	1.4	3.2	5	28	115	1.4
	Sept	2.28	1.8	3.9	5	23	80	1.6
Mo: St. Louis	July	2.43	1.7	3.6	5	34	75	1.9
	Aug	2.65	1.9	4.5	5	34	65	1.9
	Sept	2.38	1.9	3.8	5	26	105	1.7
Ohio: Cleveland	July	1.42	1.0	2.3	5	17	55	0.7
	Aug	1.39	0.8	2.5	5	11	55	1.0
	Sept	1.89	1.1	3.2	5	17	95	1.1
Pa: Pittsburgh	July	[b] 2.33	1.4	3.7	10	23	80	1.9
	Aug	2.35	1.2	3.3	10	28	95	1.4
	Sept	[b] 2.41	1.4	3.4	5	19	95	1.9
S.C: Charleston	July	1.02	0.6	1.3	5	15	40	NA
	Aug	1.83	1.3	2.0	5	37	100	NA
	Sept	1.50	1.0	2.4	5	27	85	NA
S.Dak: Sioux Falls	July	1.84	1.7	3.3	20	31	140	1.1
	Aug	1.72	1.4	2.8	5	28	85	1.2
	Sept	1.67	1.0	2.7	5	20	100	0.8
Tex: Austin	July	2.00	1.0	2.0	5	16	40	NA
	Aug	[b] 1.06	0.4	1.2	5	8	25	NA
	Sept	1.25	0.9	2.5	5	15	40	NA
Vt: Burlington	July	1.27	1.1	1.8	5	17	85	0.9
	Aug	1.32	1.3	2.6	5	26	80	0.9
	Sept	1.45	0.9	2.3	5	14	60	0.9
Wash: Seattle	July	[c] 1.55	1.1	2.6	5	31	125	0.6
	Aug	[c] 1.49	1.2	3.0	5	34	90	0.3
	Sept	[b] 1.72	1.2	3.4	5	26	105	0.7
Institutional average	July	1.83	1.3	2.6	5	25	90	1.0
	Aug	1.90	1.3	2.9	5	24	95	1.0
	Sept	1.76	1.2	2.8	5	21	85	1.0

[a] Does not contain milk portion of diet (lost in shipment).
[b] Data for these months were not used in the average, because food samples were collected from children over 12 years of age.
[c] Data for these months were not used in the average, because food samples were collected from children whose ages were unknown.
NA, no analysis
NS, no sample

Cesium–137 intakes were observed to steadily decrease during this period following the peak observed in 1964 (*4*). During this period, both barium–140 and iodine–131 concentrations were below detectable levels.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–March 1964	October 1964
April–June 1964	January 1965
July–September 1964	April 1965
October–December 1964	July 1965
Annual averages 1964	July 1965
January–March 1965	October 1965
April–June 1965	February 1966

REFERENCES

(*1*) ANDERSON, E. C., and D. J. NELSON, JR. Surveillance for radiological contamination in foods. Amer J Public Health 52:1391–1400 (September 1962).

(*2*) DIVISION OF RADIOLOGICAL HEALTH, PUBLIC HEALTH SERVICE. Radionuclides in institutional total diet samples, January-March 1965. Rad Health Data 6:548–554 (October 1965).

(*3*) DIVISION OF RADIOLOGICAL HEALTH, PUBLIC HEALTH SERVICE. Radionuclides in institutional total diet samples, April-June 1965. Rad Health Data and Reports 7:92–98 (February 1966).
ports 7:92–98 (February 1966).

(*4*) GRUNDY, R. D., C. CALVERT, and A. G. BERGER. Summary of results of Institutional Total Diet Sampling Network, 1961–1964. Rad Health Data 6: 691–698 (December 1965).

(*5*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Section II. Water

The Public Health Service, the Federal Water Pollution Control Administration, and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and/or treated (drinking) water. Most of these programs include determinations of gross alpha and gross beta radioactivity and/or specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These Standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for radium–226 and strontium–90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be higher if total intake of radioactivity from all sources indicates that such intakes are within the limits recommended by FRC for control action. In the known absence[1] of strontium–90 and alpha emitters, the limit is 1,000 pCi/liter gross beta activity. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water programs previously reported in *Radiological Health Data and Reports* are listed below:

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha emitters and strontium–90, respectively.

Program	Period reported	Last presented
Radiostrontium in Tap Water (HASL)	January–June 1965	December 1965
Colorado River Basin	1962–1964	November 1965
Coast Guard Water Sampling	1964	November 1965
Drinking Water Analysis	1962	October 1965
California Water Sampling	January–June 1965	March 1966
Florida Water Sampling	1964	November 1965
Kentucky Water Sampling	May 1963–June 1964	March 1965
Minnesota Surface Water Sampling	January–June 1965	February 1966
New York Surface Water Sampling	January–June 1965	January 1966
North Carolina Water Sampling	1964	November 1965
Lower Columbia River Radiological Survey in Oregon	August 1963–July 1964	October 1965

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, Revised 1962. Public Health Service Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation protection guidance for Federal agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

GROSS RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, NOVEMBER 1965

Basic Data Program, Federal Water Pollution Control Administration

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as a part of the Public Health Service Water Pollution Surveillance System. Responsibility for this activity was transferred to the Federal Water Pollution Control Administration on December 31, 1965. Table 1 presents the current preliminary results of the alpha and beta analysis. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium–90 results are reported quarterly. The stations on each river are arranged in the table acording to their distance from the headwaters. Figure 1 indicates the average total beta activity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the December 1965 issue of *Radiological Health Data.*

Complete data and exact sampling locations are published in annual compilations (*1–6*) or are available on request.

Special note is taken when the alpha radioactivity is 15 pCi/liter or greater, or when the beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data and for comment on the data, if needed. They reflect no public health significance, as the Public Health Service drinking water standards have already provided the basis for this assessment. Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. No discussion of gross radioactivity per gram of dissolved or suspended solids for all stations of the Water Pollution Surveillance System will be attempted at this

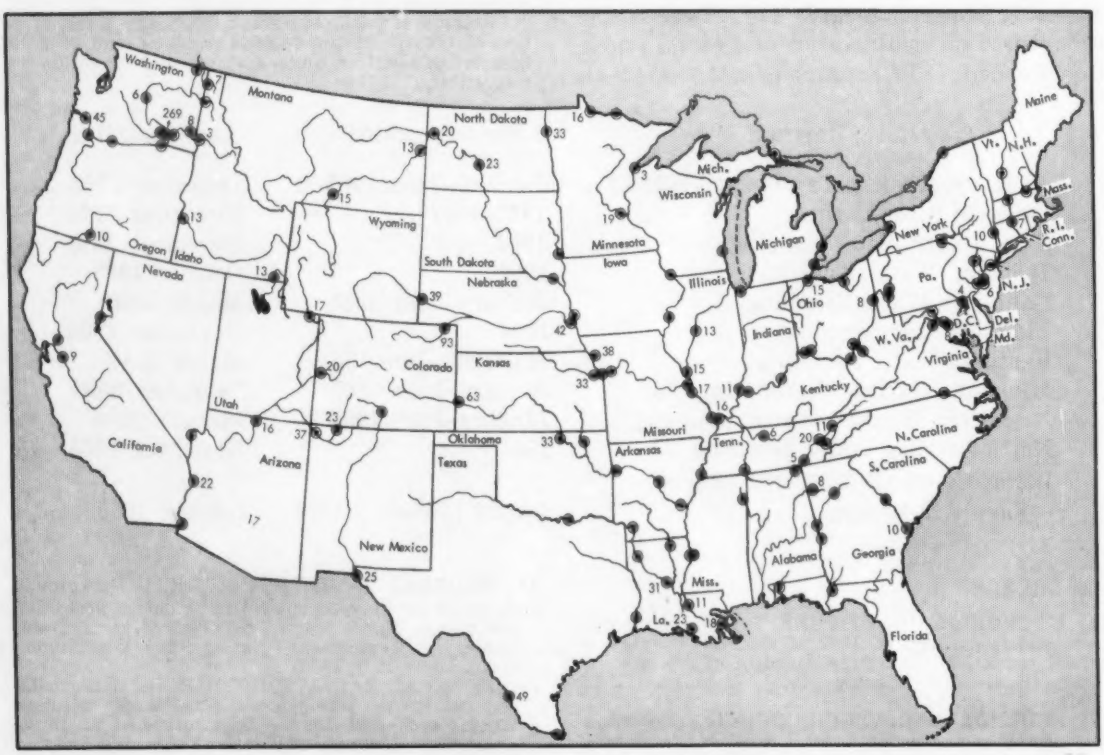

Figure 1. Sampling locations and associated total beta activity (pCi/liter) in surface waters, November 1965

time. Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During October and November 1965, the following stations showed alpha values in excess of 15 pCi/liter or beta values in excess of 150 pCi/liter in either the dissolved or suspended solids:

South Platte River:	Julesburg, Colorado
North Platte River:	Henry, Nebraska
Arkansas River:	Coolidge, Kansas
Columbia River:	Pasco, Washington

The following stations showed a decline in alpha radioactivity on suspended solids to values of 15 pCi/liter or less:

Rio Grande:	Laredo, Texas
San Juan River:	Shiprock, New Mexico

REFERENCES

(1) DIVISION OF WATER SUPPLY AND POLLUTION CONTROL, PUBLIC HEALTH SERVICE. National water quality network annual compilation of data. PHS Publication No. 663, 1958 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
(2) Ibid., 1959 Edition.
(3) Ibid., 1960 Edition.
(4) Ibid., 1961 Edition.
(5) Ibid., 1962 Edition.
(6) DIVISION OF WATER SUPPLY AND POLLUTION CONTROL, PUBLIC HEALTH SERVICE. Water pollution surveillance system, annual compilation of data. PHS Publication No. 663 (Revised) 1963 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Table 1. Radioactivity in raw surface waters, November 1965

Station	Average concentrations, pCi/liter					
	Beta			Alpha		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex.	10	13	23	2	2	4
Arkansas River:						
Coolidge, Kans.	16	47	63	3	37	40
Ponca City, Okla.	12	21	33	2	8	10
Atchafalaya River:						
Morgan City, La.	7	16	23	2	1	3
Bear River:						
Preston, Idaho	1	12	13	0	4	4
Big Horn River:						
Hardin, Mont.	3	12	15	0	7	7
Chena River:						
Fairbanks, Alaska	1	2	3	0	0	0
Clearwater River:						
Lewiston, Idaho	<1	3	3	0	0	0
Clinch River:						
Clinton, Tenn.	1	10	11	0	1	1
Kingston, Tenn.	4	16	20	<1	<1	<1
Colorado River:						
Loma, Colo.	8	12	20	2	6	8
Page, Ariz.	1	15	16	0	3	3
Parker Dam, Calif.-Ariz.	1	21	22	0	12	12
Columbia River:						
Wenatchee, Wash.	0	6	6	0	1	1
Pasco, Wash.	52	217	269	0	<1	<1
Clatskanie, Ore.	5	40	45	0	1	1
Connecticut River:						
Enfield Dam, Conn.	1	6	7	0	0	0
Coosa River:						
Rome, Ga.	3	5	8	<1	0	<1
Cumberland River:						
Cheatham Lock, Tenn.	1	5	6	0	0	0
Delaware River:						
Philadelphia, Pa.	1	5	6	1	0	1
Great Lakes:						
Duluth, Minn.	0	3	3	0	0	0
Green River:						
Dutch John, Utah	1	16	17	0	4	4
Hudson River:						
Poughkeepsie, N.Y.	2	8	10	0	0	0
Illinois River:						
Peoria, Ill.	3	10	13	1	2	3
Grafton, Ill.	1	14	15	1	2	3
Kansas River:						
DeSoto, Kans.	9	24	33	4	4	8
Klamath River:						
Keno, Ore.	3	7	10	0	0	0
Maumee River:						
Toledo, Ohio	4	11	15	1	0	1
Mississippi River:						
St. Paul, Minn.	2	17	19	0	1	1
E. St. Louis, Ill.	4	13	17	1	2	3
New Roads, La.	5	6	11	1	2	3
New Orleans, La.	3	15	18	0	2	2
Missouri River:						
Williston, N. Dak.	3	17	20	0	4	4
Bismarck, N. Dak.	5	18	23	1	4	5
St. Joseph, Mo.	16	22	38	4	6	10
North Platte River:						
Henry, Nebr.	3	36	39	<1	26	26
Ohio River:						
Toronto, Ohio	1	7	8	0	0	0
Cairo, Ill.	3	13	16	0	0	0
Pend Oreille River:						
Albeni Falls Dam, Idaho	1	6	7	0	1	1
Platte River:						
Plattsmouth, Nebr.	15	27	42	4	10	14
Potomac River:						
Washington, D.C.	1	7	8	0	0	0
Rainy River:						
Baudette, Minn.	2	14	16	<1	<1	<1
Red River, North:						
Grand Forks, N. Dak.	2	31	33	0	3	3
Red River, South:						
Alexandria, La.	9	22	31	3	2	5
Rio Grande:						
El Paso, Tex.	2	23	25	0	5	5
Laredo, Tex.	33	16	49	12	5	17
San Joaquin River:						
Vernalis, Calif.	1	8	9	0	3	3
San Juan River:						
Shiprock, N. Mex.	27	10	37	10	2	12
Savannah River:						
Port Wentworth, Ga.	2	8	10	0	0	0
Snake River:						
Payette, Idaho	1	12	13	0	5	5
Wawawai, Wash.	0	8	8	0	3	3
South Platte River:						
Julesburg, Colo.	28	65	93	8	38	46
Susquehanna River:						
Conowingo, Md.	0	4	4	0	0	0
Tennessee River:						
Chattanooga, Tenn.	0	5	5	0	1	1
Wabash River:						
New Harmony, Ind.	4	7	11	0	1	1
Yellowstone River:						
Sidney, Mont.	2	11	13	0	3	3
Maximum	52	217	269	12	38	46
Minimum	0	2	3	0	0	0

RADIOACTIVITY IN WASHINGTON SURFACE WATER JULY 1964–JUNE 1965[1]

Washington State Department of Health

Radioanalysis of surface water samples collected throughout the State of Washington is one of the major functions of the Washington State Department of Health radiation surveillance program. Most surface water samples are collected quarterly from 70 stations located on 59 rivers throughout the State. These samples are collected by the Washington Pollution Control Commission and are sent to the Department of Health for radiological analyses. A few locations are sampled less frequently, and selected stations on the Columbia River are sampled weekly by local health department sanitarians.

All surface water samples are collected as grab samples in 2-liter plastic bottles. Two milliliters of concentrated nitric acid are added to the sample before shipment to the laboratory to prevent loss of activity to the container.

Analytical procedures

Surface water samples are placed in stainless-steel Marinelli beakers for the gamma analyses. Distilled water is added when necessary to obtain 2-liter volumes for standardizing counting geometry. These samples are gamma scanned for 100 minutes approximately 2 weeks after collection. This 2-week period permits the decay of short-lived isotopes (sodium–24, arsenic–76, neptunium–239) in Columbia River water samples. The matrix method, utilizing a 4 by 4 matrix, permits the estimation of chromium–51, ruthenium–106, zirconium–95, and zinc–65. Results are extrapolated to the date of collection.

The gamma-counting equipment consists of a 3 by 3-inch gamma-scintillation crystal and a 512-channel analyzer. A 1-minute count each day of a cesium–137 standard is performed as an efficiency check, and a 10-minute count each week is done to check the resolution. An 800-minute count each week is taken to check the background. Table 1 gives the gamma efficiencies and detectability limits for this system.

After the gamma scan, the water samples receive further preparation and are beta counted approximately 18 days after sample collection for suspended and soluble radioactivity. The separation of dissolved and suspended activity is accomplished by filtering the acidified sample (Whatman #42 filter paper). The filtrate, evaporated to near dryness, is quantitatively transferred to a tared planchet and dried for gross beta counting. The filter paper containing the suspended activity is ashed in a muffle furnace at 600°C. and transferred to a planchet for gross beta counting.

[1] Summarized from "Environmental Radiation Surveillance in Washington State, Fourth Annual Report, December 1965"(*1*).

Table 1. Beta and gamma efficiencies and detectability limits for the Washington State analysis

Radionuclide	Energy band (MeV)	Efficiency (percent)	Average background (cpm)	Detectability limits (pCi)
Beta				
Strontium-yttrium-90	—	33	0.5	[a] 0.27
Yttrium-90	—	37	0.5	[a] 0.24
Phosphorus-32	—	34	0.5	[a] 0.26
Gamma				
Cesium-137	0.62–0.72	2.50	12.37	[b] 30
Chromium-51	0.30–0.36	0.45	25.03	[b] 220
Ruthenium-106	0.44–0.56	0.94	24.52	[b] 100
Zirconium-95	0.73–0.79	6.00	6.33	[b] 10
Zinc-65	1.05–1.17	0.94	6.92	[b] 50

[a] Amount of radiation necessary to produce a net cpm equal to 2 sigma of background, based on 100-minute counts.
[b] Amount of radiation necessary to produce a net cpm equal to 4 sigma of the respective background, based on 100-minute counts.

Counting time is 100 minutes. After obtaining the net beta-counting rate, corrections for self absorption and efficiency are made and the results converted to concentrations in water. Gross beta results are not extrapolated to date of collection.

In addition to the above analyses, water samples from the Columbia River are also analyzed for phosphorus–32. The technique used for phosphorus–32 separation is a modification of published methods (*2–5*). After the sample has been stored for 15 days, which allows arsenic–76 and other short-lived interfering radionuclides to decay, the phosphorus is separated by precipitation as ammonium phosphomolybdate in an acid medium. The precipitate is washed with ammonium nitrate, dissolved with 3*N* ammonium hydroxide, transferred to a tared planchet, ashed, weighed, and counted for beta activity. The counting rate is corrected for self absorption, phosphorus–32 efficiency, and the decay rate. The results are converted to concentrations in water.

Beta counting is done with a low-background beta system including a 2-inch detector and automatic sample changer. This system has an average background of 0.5 counts per minute. Background counts are performed as an integral part of each sample. Gross beta calibration of the instrument is done with a strontium–yttrium–90 standard.

Results

Table 2 presents the monthly average results for the Columbia River stations which are sampled routinely. In averaging, a less-than value is assumed to be equal to its numerical value and a less-than sign is placed in front of the average.

Table 3 summarizes the beta activity measurements from the 64 other surface water stations from July 1964 through June 1965. The second column in this table gives code numbers and the abbreviations denoting geographical sections (in figure 1). Each river is assigned a four-digit number; the first two digits indicate the river and the second two digits indicate the sampling stations on the river. For example, code number 04 refers to the Snake River in the area designated "RSE", i.e., Southeast. The code number 01 refers to the first sampling station on that river. The third column gives the total number of samples analyzed.

Gamma scans of the samples in table 3 indicated no detectable activity in any sample.

The network summary gives the maximum and minimum values for the 226 samples analyzed, while the network average is obtained by averaging all the station average values.

Discussion

Of the 226 river water samples analyzed from July 1964 through June 1965 (excluding the Columbia River), the total beta activity ranged from 1 to 24 pCi/liter with an average of 5.3 pCi/liter. The activity of the suspended fraction ranged from <1 to 11 pCi/liter with an average of <1 pCi/liter. The activity of the soluble fraction was slightly higher, ranging from <1 to 16 pCi/liter and averaging 4.3 pCi/liter. These network averages during the July 1964 through June 1965 period were lower by about a factor of two than the averages for the preceding 12 months.

Monthly average total beta activity for the Columbia River stations below the Hanford Facility ranged from 16 to 1,430 pCi/liter. Monthly average concentrations of the beta emitter, phosphorus–32, in the Columbia River water samples taken below the Hanford Facility ranged from 8 to 599 pCi/liter.

The gamma emitters ruthenium–106 and zirconium–95 were found in monthly average concentrations that ranged from <50 to 223 pCi/liter for ruthenium–106 and <5 to 22 pCi/liter for zirconium–95. The values for ruthenium–106 are probably a combination of ruthenium–103 and ruthenium–106. Two other radionuclides, chromium–51 and zinc–65, were found in detectable quantities in Columbia River water. Monthly averages for chromium–51 ranged from 326 to 18,719 pCi/liter and for zinc–65 the range was <25 to 708 pCi/liter.

Although any standards for gross beta activity must be very carefully applied, the standard for drinking water is 1,000 pCi/liter of beta activity, in the absence of strontium–90 and alpha emitters (*6*). The standards for water from all dietary sources for the general population at large (*7*) are, chromium–51, 670,000 pCi/liter; ruthenium–106, 3,300 pCi/liter; zirconium–95, 20,000 pCi/liter; zinc–65, 10,000 pCi/liter and phosphorus–32, 7,000 pCi/liter.

Table 2. Beta activity in Washington surface water (except for Columbia River), July 1964–June 1965

Sampling location	Code number	Number of samples	Concentrations, pCi/liter								
			Suspended [a]			Dissolved [a]			Total		
			Average	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum
Baker River	RNW 0401	4	1	<1	3	8	3	13	9	4	16
Big Quilcene River	RPS 2201	2	<1	<1	<1	<1	<1	1	1	1	2
Bumping River	RSC 1001	1	<1	<1	<1	3	3	3	4	4	4
Cedar River	RPS 0201	12	<1	<1	<1	2	<1	3	2	1	4
Chehalis River	RSW 0601	4	<1	<1	<1	3	1	5	4	2	6
	RCP 0401	4	<1	<1	<1	2	2	3	3	3	4
											4
Chico Creek	RPS 3101	3	1	<1	2	6	4	7	7	5	
Cloquallam River	RCP 0101	6	<1	<1	<1	2	1	4	3	2	9
Colville River	RNE 0801	3	<1	<1	1	7	6	8	8	7	5
Coweman River	RSW 0501	3	<1	<1	<1	3	1	4	3	2	9
Cowlitz River	RSW 0701	4	1	<1	3	5	1	10	6	2	5
Crab Creek	RSC 0102	1	2	2	2	16	16	16	18	18	13
											18
Deschutes River	RPS 1502	3	<1	<1	<1	[b] 3	2	4	[b] 4	3	
Dosewallips River	RPS 2301	2	<1	<1	<1	2	1	2	2	2	5
Duckabush River	RPS 2401	2	<1	<1	<1	6	1	11	7	2	3
Dungeness River	RCP 0301	2	<1	<1	<1	2	1	2	2	2	12
Duwamish River	RPS 0601	4	<1	<1	2	[b] 4	3	5	[b] 5	4	3
Elwha River	RCP 0201	2	<1	<1	<1	2	1	3	3	2	6
											4
Goldsborough Creek	RPS 3001	2	<1	<1	<1	2	1	3	3	2	
Green River	RPS 0501	4	<1	<1	1	3	1	5	3	2	4
Hamma Hamma River	RPS 2601	2	<1	<1	<1	6	<1	12	7	1	6
Hoh River	RCP 0801	2	<1	<1	<1	3	2	3	3	3	13
Humptulips River	RCP 0701	4	<1	<1	<1	2	<1	3	2	1	4
Issaquah Creek	RPS 2901	3	<1	<1	<1	2	2	3	3	3	4
Kalama River	RSW 0301	3	<1	<1	<1	2	1	3	3	2	4
Kettle River	RNE 0701	3	<1	<1	<1	3	3	4	4	4	5
Lake Washington	RPS 2801	3	<1	<1	<1	8	6	9	8	7	10
Little Spokane River	RNE 1001	8	<1	<1	2	5	3	7	6	4	8
Newaukum River	RSW 0401	3	<1	<1	<1	5	2	6	5	3	7
Nisqually River	RPS 1401	3	<1	<1	<1	7	2	9	7	3	10
Nooksack River	RNW 0101	4	3	<1	10	6	3	11	9	4	21
N. Stillaguamish River	RPS 1601	4	2	<1	5	5	2	9	7	3	14
Pend Oreille River	RNE 0201	8	<1	<1	<1	5	3	6	5	4	7
	RNE 0203	3	<1	<1	<1	5	4	7	6	5	8
Puyallup River	RPS 1301	4	1	<1	3	6	2	13	7	3	16
Queets River	RCP 1301	2	<1	<1	<1	3	2	3	3	3	4
Quinault River	RCP 1401	2	<1	<1	<1	3	2	4	4	3	5
Samish River	RNW 0301	4	1	<1	3	6	2	11	7	3	14
Sammamish River	RPS 0701	4	2	<1	3	6	4	7	8	5	10
Sanpoil River	RNE 0901	3	<1	<1	1	3	2	4	3	3	5
Satsop River	RCP 1201	4	<1	<1	<1	1	<1	2	2	1	3
Skagit River	RNW 0201	4	2	<1	3	6	3	10	7	4	12
Skokomish River	RPS 2501	2	<1	<1	<1	1	<1	2	4	1	3
Skykomish River	RPS 1101	4	<1	<1	<1	4	2	5	2	3	6
Snake River	RSE 0401	4	1	1	2	6	3	9	7	5	10
	RSE 0402	2	5	2	8	8	7	8	13	10	15
Snohomish River	RPS 0401	4	<1	<1	1	[b] 5	2	10	[b] 6	3	11
Snoqualmie River	RPS 1201	4	<1	<1	<1	4	3	4	4	4	5
Soleduck River	RCP 0901	2	<1	<1	<1	2	1	2	2	2	3
S. Stillaguamish River	RPS 1001	4	2	<1	4	6	3	10	7	4	14
Spokane River	RNE 0301	8	<1	<1	<1	4	2	6	5	3	7
	RNE 0302	8	1	<1	6	4	2	6	5	3	12
Stillaguamish River	RPS 0301	4	4	<1	11	6	2	13	9	3	24
Sultan River	RPS 0901	4	<1	<1	1	5	3	9	6	4	10
Teanaway River	RSC 0301	1	<1	<1	<1	2	2	2	3	3	3
Tolt River	RPS 2001	4	<1	<1	2	3	2	5	4	3	6
Toutle River	RSW 0201	3	<1	<1	<1	3	2	4	4	3	5
Walla Walla River	RSE 0501	3	5	1	8	7	6	9	12	8	17
Whatcom Lake	RNW 0601	3	<1	<1	<1	6	5	7	7	6	8
White River	RPS 0801	4	3	<1	7	6	2	10	8	3	17
Wynoochee River	RCP 0601	4	<1	<1	<1	1	<1	2	2	1	3
Yakima River	RSC 0201	1	<1	<1	<1	4	4	4	5	5	5
	RSC 0202	1	<1	<1	<1	5	5	5	6	6	6
	RSE 0201	4	<1	<1	2	4	3	6	5	4	7
Network summary		226	<1	<1	11	4.3	<1	16	5.3	1	24

[a] For averaging purposes, <1 is assumed to be equal to 0.5. Averages less than one are recorded as <1.
[b] Sample contaminated in laboratory—not included in average.

Table 3. Monthly average radioactivity in Columbia River water July 1964–June 1965

Location and type of analysis	Concentrations, pCi/liter											
	1964						1965					
	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
Northport (code no. RNE 0601)												
Beta												
Suspended [a]	NS	NS	NS	<1	NS	<1	NS	<1	NS	NS	NS	NS
Dissolved [a]	NS	NS	NS	8	NS	6	NS	4	NS	NS	NS	NS
Total [a]	NS	NS	NS	<9	NS	<7	NS	<5	NS	NS	NS	NS
Phosphorus-32 [b]	NS	NS	NS	<1	NS	<1	NS	<1	NS	NS	NS	NS
Gamma [b]												
Chromium-51	NS	NS	NS	<110	NS	<110	NS	<110	NS	NS	NS	NS
Ruthenium-106 [c]	NS	NS	NS	<50	NS	<50	NS	<50	NS	NS	NS	NS
Zirconium-95	NS	NS	NS	<5	NS	<5	NS	<5	NS	NS	NS	NS
Zinc-65	NS	NS	NS	<25	NS	<25	NS	<25	NS	NS	NS	NS
Richland (code no. RSE 0104)												
Beta												
Suspended [a]	15	121	71	754	22	27	20	28	569	71	277	328
Dissolved [a]	63	131	177	314	189	300	242	174	861	376	308	150
Total [a]	78	252	248	1,068	211	327	262	202	1,430	447	585	478
Phosphorus-32 [b]	60	151	143	396	231	396	298	191	533	292	437	154
Gamma [b]												
Chromium-51	2,647	7,949	8,406	[d] 9,738	11,013	18,719	12,116	6,546	[d] 8,010	11,711	[d] 4,646	[d] 1,337
Ruthenium-106 [c]	<100	<180	163	[d] 223	<120	156	<143	110	[d] <108	176	[d] <100	[d] <100
Zirconium-95	<10	<16	<10	[d] 22	<10	<10	<10	<10	[d] <12	<14	[d] <10	[d] <10
Zinc-65	101	526	302	[d] 708	276	417	362	389	[d] 551	671	[d] 422	[d] 170
Pasco (code no. RSE 0101)												
Beta												
Suspended [a]	8	NS	112	88	15	19	29	21	42	43	32	15
Dissolved [a]	26	NS	206	193	162	214	149	103	109	183	79	34
Total [a]	34	NS	318	281	177	233	178	124	151	226	111	49
Phosphorus-32 [b]	32	NS	112	50	224	278	98	117	133	303	102	45
Gamma												
Chromium-51	1,153	NS	16,995	4,341	10,289	2,807	8,518	4,436	5,022	8,117	2,610	1,900
Ruthenium-106 [c]	<50	NS	183	222	101	87	76	<52	83	93	<50	<50
Zirconium-95	<5	NS	12	20	7	<5	<5	<5	8	6	<5	<5
Zinc-65	64	NS	255	281	276	303	359	252	332	487	187	111
McNary Dam (code no. RSE 0102)												
Beta												
Suspended [a]	NS	NS	25	NS	NS	12	NS	NS	13	NS	NS	6
Dissolved [a]	NS	NS	48	NS	NS	89	NS	NS	49	NS	NS	10
Total [a]	NS	NS	73	NS	NS	101	NS	NS	62	NS	NS	16
Phosphorus-32 [c]	NS	NS	43	NS	NS	113	NS	NS	32	NS	NS	8
Gamma												
Chromium-51	NS	NS	5,242	NS	NS	6,251	NS	NS	2,139	NS	NS	326
Ruthenium-106 [c]	NS	NS	67	NS	NS	<50	NS	NS	<50	NS	NS	<60
Zirconium-95	NS	NS	<5	NS	NS	<5	NS	NS	<5	NS	NS	<6
Zinc-65	NS	NS	72	NS	NS	139	NS	NS	96	NS	NS	<30
Washougal (code no. RSW 0903)												
Beta												
Suspended [a]	13	12	8	8	8	12	13	17	14	43	12	10
Dissolved [a]	20	28	30	32	35	45	42	35	53	48	31	21
Total [a]	33	40	38	40	43	57	55	52	67	91	43	31
Phosphorus-32 [b]	19	18	13	23	36	50	39	37	63	63	40	28
Gamma [c]												
Chromium-51	1,212	2,631	3,259	3,426	3,010	2,884	2,391	2,323	2,372	2,354	1,177	1,023
Ruthenium-106 [c]	<78	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Zirconium-95	<5	<5	<5	<5	<5	<5	<5	<7	<5	<5	<5	<5
Zinc-65	67	<36	<25	<29	<25	53	56	90	194	106	56	<50
Vancouver (code no. RSW 0102)												
Beta												
Suspended [a]	27	13	8	9	8	12	9	18	16	24	14	10
Dissolved [a]	23	29	29	31	35	42	41	30	45	46	28	21
Total [a]	50	42	37	40	43	54	50	48	61	70	42	31
Phosphorus-32 [b]	22	18	13	[e] 20	31	49	46	35	59	60	40	24
Gamma [b]												
Chromium-51	1,339	2,526	3,434	3,447	2,808	2,710	2,359	2,299	2,209	2,332	1,191	1,022
Ruthenium-106 [c]	<52	<50	<50	<50	<52	<51	<51	<50	<50	<50	<50	<50
Zirconium-95	<6	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Zinc-65	75	<45	27	<32	<41	<54	57	88	94	116	54	45

[a] Activity at time of counting. ^{90}Sr–^{90}Y calibration standard in suspended and dissolved solids acidified.
[b] Results extrapolated to date of sample.
[c] Net activity in the 0.44–0.56 MeV gamma range is assumed to be only ruthenium-106.
[d] Scandium-46 contaminated sample not included in average.
[e] Contaminated sample not included in average.
NS, no samples collected.

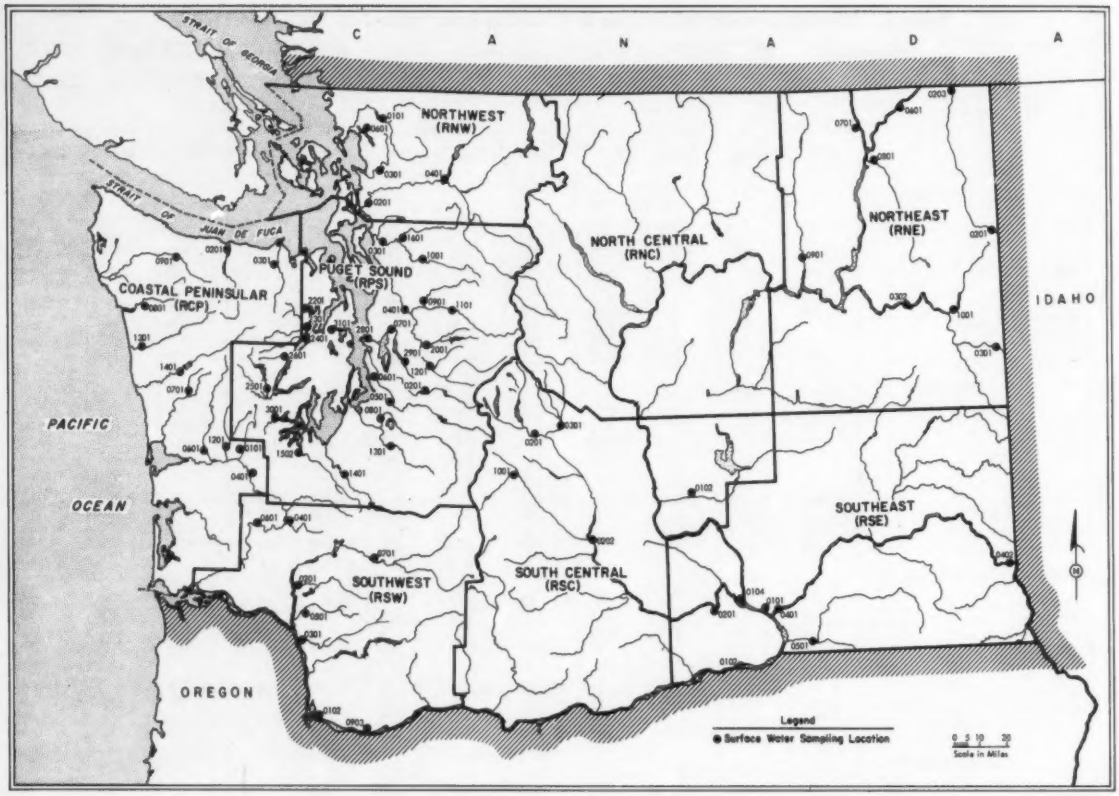

Figure 1. Washington surface water sampling locations

REFERENCES

(*1*) MOONEY, R. R., and P. W. HILDEBRANDT. Environmental radiation surveillance in Washington State. Washington State Department of Health, Olympia, Washington (December 1965). Limited distribution.

(*2*) KOLTHOFF, I. M., and E. B. SANDELL. Textbook of Quantitative Inorganic Analysis, Revised Edition, pp. 390–397; 713–717. The McMillan Company, New York (1949).

(*3*) HILLEBRAND, W. F., and G. LUNDELL. Applied Inorganic Analysis, pp. 694–710. John Wiley and Sons, Inc., New York (1953).

(*4*) FURMAN, N. H., Editor. Scott's Standard Method of Analysis, 5th Edition, pp. 694–697. Von Nostrand Company, Inc., New York (1944).

(*5*) HANFORD ATOMICS PRODUCTS OPERATION. Radiological chemical analysis: river analysis manual—phosphorus–32 determination. Hanford Facility, Richland, Washington.

(*6*) PUBLIC HEALTH SERVICE. Public Health Service drinking water standards, Revised 1962. PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (August 1963).

(*7*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Report of Committee II on permissible dose for internal radiation. Pergamon Press, New York (1959).

Previous coverage in *Radiological Health Data:*

Period	*Issue*
July 1962–June 1963	August 1964
July 1963–June 1964	February 1965

Section III. Air and Deposition

RADIOACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product activity. To date, this surveillance has been confined chiefly to gross beta analysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used for determining when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson (*1*) in 1962. In addition to these programs presented in this issue, the results of other air and deposition programs have been previously covered in *Radiological Health Data and Reports:*

Program	Period reported	Last presented
National Air Sampling Network	October–December and Annual Summary 1965	April 1966
Mexican Air Monitoring	November 1965	March 1966

1. Radiation Surveillance Network January 1966

Division of Radiological Health
Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) which regularly gathers samples from 74 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Daily samples of airborne particulates and precipitation are forwarded to the Radiation Surveillance Network Laboratory in Rockville, Maryland, for laboratory analysis. The alerting function of the network is provided by routine field estimates of the gross beta activity made by the station operators prior to submission of the samples. When high air levels are reported, appropriate officials are promptly notified. Compilation of field estimates and laboratory confirmations are reported elsewhere on a monthly basis (*2*). A detailed description of the sampling and analysis procedures was presented in the December 1965 issue of *Radiological Health Data.*

Table 1 presents the monthly average gross beta activity in surface air and deposition by precipitation during January 1966. Time profiles of gross beta in air dating back to 1958 for eight RSN stations are shown in figure 2. Gamma spectroscopy analysis was performed on 298 air samples. No traces of fresh fission products were identified in these samples.

Figure 1. Radiation Surveillance Network sampling stations

Table 1. Gross beta activity in surface air and precipitation, January 1966

Station location		Air surveillance						Precipitation	
		Number of samples		Gross beta activity, pCi/m³			Last profile in RHD &R	Total depth (mm)	Total deposition (nCi/m²)
		Air	Pptn	Maximum	Minimum	Average [a]			
Ala:	Montgomery	31	8	0.13	<0.10	<0.10	Feb 66	168	<34
Alaska:	Adak	29		<0.10	<0.10	<0.10	Sep 65	[b]	
	Anchorage	16	1	0.12	<0.10	<0.10	Mar 66	2	<0
	Attu Island	7		0.24	<0.10	<0.13	Oct 65	[b]	
	Fairbanks	5		<0.10	<0.10	<0.10	Apr 66	[b]	
	Juneau	20	5	0.24	<0.10	<0.12	July 65	95	<19
	Kodiak	11		<0.10	<0.10	<0.10	May 66	[b]	
	Nome	2		<0.10	<0.10	<0.10	Dec 65	[b]	
	Pt. Barrow	28		<0.10	<0.10	<0.10	Nov 65	[b]	
	St. Paul Island	13		<0.10	<0.10	<0.10	Jan 66	[b]	
Ariz:	Phoenix	31		0.16	<0.10	<0.11	July 65	[b]	
Ark:	Little Rock	19	3	<0.10	<0.10	<0.10	Mar 66	66	<13
Calif:	Berkeley	21	4	0.16	<0.10	<0.11	May 66	116	<23
	Los Angeles	21	1	0.13	<0.10	<0.10	Dec 65	26	<5
C.Z:	Ancon	16		<0.10	<0.10	<0.10	May 66	[b]	
Colo:	Denver	30		0.17	<0.10	<0.11	May 66	[b]	
Conn:	Hartford	31	8	<0.10	<0.10	<0.10	Apr 66	45	<9
Del:	Dover	18		<0.10	<0.10	<0.10	Feb 66	[b]	
D.C:	Washington	28	6	<0.10	<0.10	<0.10	Nov 65	63	<13
Fla:	Jacksonville	30	10	0.12	<0.10	<0.10	Mar 66	121	<24
	Miami	28	7	0.18	<0.10	<0.11	Apr 66	90	<18
Ga:	Atlanta	[c]	1				Jan 66	13	<3
Guam:	Agana	31		0.14	<0.10	<0.10	Feb 66	[b]	
Hawaii:	Honolulu	30	3	0.12	<0.10	<0.10	Oct 65	72	<14
Idaho:	Boise	31	6	0.20	<0.10	<0.11	Oct 65	25	<6
Ill:	Springfield	26	1	0.12	<0.10	<0.10	Nov 65	10	<2
Ind:	Indianapolis	26	2	<0.10	<0.10	<0.10	Jan 66	85	<17
Iowa:	Iowa City	28	4	<0.10	<0.10	<0.10	May 66	32	<6
Kans:	Topeka	31	1	<0.10	<0.10	<0.10	Mar 66	8	<2
Ky:	Frankfort	27	5	0.13	<0.10	<0.10	Nov 65	32	<6
La:	New Orleans	30	12	0.13	<0.10	<0.10	Nov 65	353	<71
Maine:	Augusta	31	13	<0.10	<0.10	<0.10	Dec 65	159	<32
	Presque Isle	13		<0.10	<0.10	<0.10	May 66	[b]	
Md:	Baltimore	20	4	0.13	<0.10	<0.10	Apr 66	33	<7
	Rockville	11		0.19	<0.10	<0.12	Oct 65	[b]	
Mass:	Lawrence	31	6	0.11	<0.10	<0.10	Feb 66	77	<15
	Winchester	29	13	<0.10	<0.10	<0.10	Sep 65	107	<21
Mich:	Lansing	30		<0.10	<0.10	<0.10	Oct 65	[b]	
Minn:	Minneapolis	21	8	<0.10	<0.10	<0.10	Feb 66	22	<4
Miss:	Jackson	30	8	0.11	<0.10	<0.10	Dec 65	148	<30
Mo:	Jefferson City	28	2	<0.10	<0.10	<0.10	Jan 66	24	<5
Mont:	Helena	30	8	0.17	<0.10	<0.11	Sep 65	15	<3
Nebr:	Lincoln	19		0.21	<0.10	<0.12	Jan 66	[b]	
Nev:	Las Vegas	27		0.17	<0.10	<0.11	Apr 66	[b]	
N.H:	Concord	19		<0.10	<0.10	<0.10	Nov 65	[b]	
N.J:	Trenton	29	6	<0.10	<0.10	<0.10	Dec 65	25	<5
N.Mex:	Santa Fe	28	3	0.12	<0.10	<0.10	Sep 65	11	<2
N.Y:	Albany	17	4	<0.10	<0.10	<0.10	Jan 66	26	<5
	Buffalo	30		<0.10	<0.10	<0.10	May 66	[b]	
	New York	21		<0.10	<0.10	<0.10	Sep 65	[b]	
N.C:	Gastonia	28	10	<0.10	<0.10	<0.10	May 66	58	<12
N.Dak:	Bismarck	29	4	0.11	<0.10	<0.10	Nov 65	8	<2
Ohio:	Cincinnati	19		<0.10	<0.10	<0.10	Feb 66	[b]	
	Columbus	29	5	0.12	<0.10	<0.10	Dec 65	83	<17
	Painesville	30	7	<0.10	<0.10	<0.10	Apr 66	35	<8
Okla:	Oklahoma City	30	5	<0.10	<0.10	<0.10	Oct 65	12	<2
	Ponca City	21	3	<0.10	<0.10	<0.10	Apr 66	8	<2
Ore:	Portland	31	22	0.21	<0.10	<0.11	Jan 66	115	<23
Pa:	Harrisburg	27	3	<0.10	<0.10	<0.10	Jan 66	16	<3
P.R:	San Juan	27	4	<0.10	<0.10	<0.10	Dec 65	112	<22
R.I:	Providence	29	3	<0.10	<0.10	<0.10	Oct 65	26	<5
S.C:	Columbia	31	10	0.12	<0.10	<0.10	Sep 65	143	<29
S.Dak:	Pierre	30		<0.10	<0.10	<0.10	July 65	[b]	
Tenn:	Nashville	27	11	<0.10	<0.10	<0.10	Oct 65	83	<17
Tex:	Austin	28	9	<0.10	<0.10	<0.10	Feb 66	36	<7
	El Paso	29	3	0.14	<0.10	<0.11	Nov 65	8	<2
Utah:	Salt Lake City	31	4	0.15	<0.10	<0.11	Dec 65	15	<3
Vt:	Barre	31	13	<0.10	<0.10	<0.10	Mar 66	49	<10
Va:	Richmond	31	5	<0.10	<0.10	<0.10	Mar 66	52	<10
Wash:	Seattle	31	17	<0.10	<0.10	<0.10	Mar 66	136	<27
	Spokane	31	4	<0.10	<0.10	<0.10	Feb 66	17	<3
W.Va:	Charleston	28	8	<0.10	<0.10	<0.10	Sep 65	92	<18
Wis:	Madison	31	2	<0.10	<0.10	<0.10	Mar 66	30	<6
Wyo:	Cheyenne	30	1	0.16	<0.10	<0.11	Apr 66	2	<0
Network summary		1,848	316	0.24	<0.10	<0.10		62	<12

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the "<" values represent more than 10 percent of the average, a "less-than" sign is placed before the average.
[b] Indicates no precipitation sample collected.
[c] Indicates no report received.

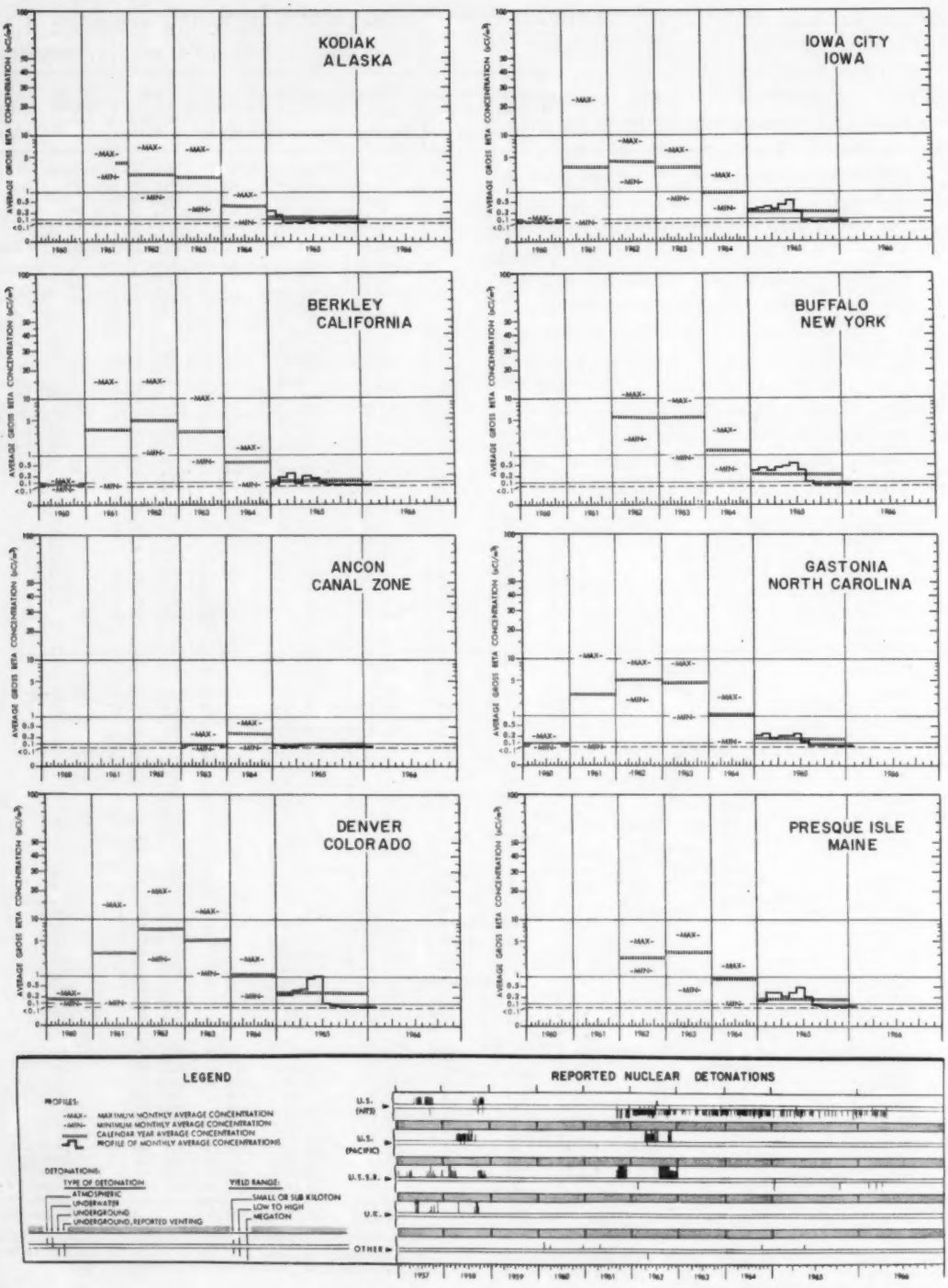

Figure 2. Monthly and yearly profiles of beta activity in air—Radiation Surveillance Network, 1960–January 1966

2. Canadian Air and Precipitation Monitoring Program January 1966[1]

Radiation Protection Division
Department of National Health and Welfare
Ottawa, Canada

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (see figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*3–7*).

A summary of the sampling procedures and methods of analysis was presented in the December 1965 issue of *Radiological Health Data* (*8*).

[1] Prepared from information and data in the February 1966 monthly report "Data from Radiation Protection Program," Canadian Department of National Health and Welfare, Ottawa, Canada.

Surface air and precipitation data for January 1966 are presented in table 2.

Table 2. Canadian gross beta activity in surface air and precipitation, January 1966

Station	Air Surveillance				Precipitation measurements	
	Number of samples	Activity, pCi/m³			Average concentration (pCi/liter)	Total deposition (nCi/m²)
		Maximum	Minimum	Average		
Calgary	31	0.2	0.0	0.1	52	0.5
Coral Harbour	31	0.2	0.0	0.1	54	0.9
Edmonton	31	0.1	0.0	0.1	20	0.7
Ft. Churchill	31	0.1	0.0	0.1	24	0.3
Ft. William	25	0.1	0.0	0.1	27	1.1
Fredericton	31	0.1	0.0	0.1	16	1.2
Goose Bay	31	0.1	0.0	0.0	15	0.8
Halifax	31	0.1	0.0	0.1	34	3.2
Inuvik	31	0.2	0.1	0.1	T	0.3
Montreal	30	0.1	0.0	0.1	12	1.0
Moosonee	23	0.1	0.0	0.1	8	0.5
Ottawa	31	0.1	0.0	0.1	9	0.6
Quebec	31	0.1	0.0	0.1	14	2.1
Regina	31	0.2	0.0	0.1	64	1.0
Resolute	30	0.2	0.0	0.1	171	1.3
St. John's, Nfld.	31	0.1	0.0	0.0	5	0.8
Saskatoon	31	0.2	0.0	0.1	29	0.5
Sault Ste. Marie	29	0.1	0.0	0.0	13	0.8
Toronto	31	0.1	0.0	0.1	22	1.3
Vancouver	31	0.1	0.0	0.0	27	3.1
Whitehorse	31	0.2	0.1	0.1	34	0.3
Windsor	31	0.2	0.0	0.1	37	0.8
Winnipeg	31	0.2	0.1	0.1	95	0.9
Yellowknife	31	0.1	0.1	0.1	22	0.2
Network summary	-------	0.1	0.0	0.1	35	1.0

T indicates trace

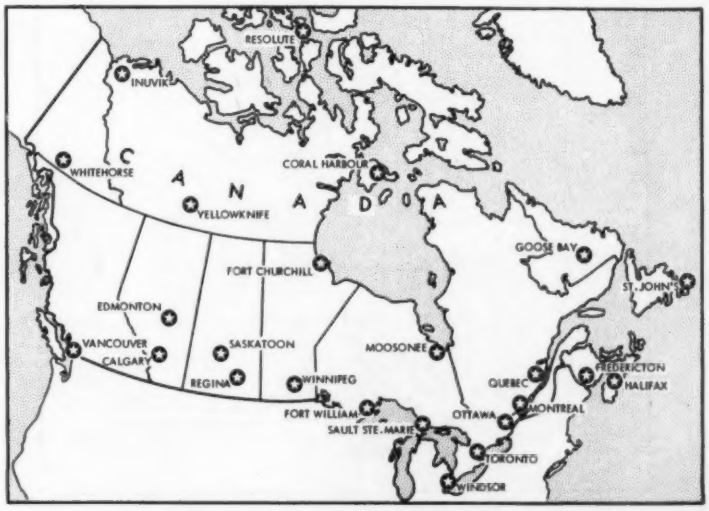

Figure 3. Canadian air and precipitation sampling stations

3. Pan American Air Sampling Program January 1966

Pan American Health Organization and Public Health Service

Gross beta activity in air is monitored by countries in the Americas under the auspices of a collaborative program developed by the Pan American Health Organization (PAHO) and the Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network. The air sampling stations are shown in figure 4.

The January 1966 air monitoring results from the participating countries are given in table 3.

Table 3. Gross beta activity in surface air, January 1966

Station location	Number of samples	Gross beta activity, pCi/m³		
		Maximum	Minimum	Average [a]
Argentina: Buenos Aires	20	0.16	<0.10	<0.11
Chile: Santiago	17	<0.10	<0.10	<0.10
Jamaica: Kingston	23	<0.10	<0.10	<0.10
Peru: Lima	22	<0.10	<0.10	<0.10
Venezuela: Caracas	21	<0.10	<0.10	<0.10
West Indies: Trinidad	17	<0.10	<0.10	<0.10
Pan American summary	120	0.16	<0.10	<0.10

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the "<" values represent more than 10 percent of the average, a "less-than" sign is placed before the average.

Figure 4. Pan American Air Network sampling stations

4. Fallout in the United States and other areas January–June 1965[1]

Health and Safety Laboratory
Atomic Energy Commission

Monthly fallout deposition rates for strontium–90 are determined by the Health and Safety Laboratory (HASL) for 49 sites in the United States and 107 locations in other countries. HASL data from all of the active United States stations and 35 other selected points in the Western Hemisphere (see figure 5) covering the period from January through June 1965 are summarized in tables 4 and 5. All the stations of the 80th Meridian Network, except Washington, D.C., are represented.

To facilitate the accurate storage, retrieval, and handling of data generated from the monthly fallout collections network, all data obtained are transcribed onto punched cards. To accomplish this transcription, several rigid criteria were applied to the data. One condition was that only monthly data are punched onto the cards. In the few cases where collections were incomplete or where collection times overlapped calendar months, the data were corrected to yield monthly values by interpolation using rainfall and observed concentrations in rainfall as guides. Where any corrections to the

[1] The data in this article were taken from *Fallout Program Quarterly Summary Report*, HASL 165:2–202, Health and Safety Laboratory, AEC, New York, N.Y. 10014.

Table 4. Strontium-90 fallout in the United States, HASL, January–June 1965

Sampling location and type of collection			Deposition, nCi/m²					
			Jan	Feb	Mar	Apr	May	June
Ala:	Birmingham	(pot)	0.27	0.05	0.95	0.54	0.38	0.84
Alaska:	Anchorage	(col)	0.06	0.03	0.19	0.05	0.02	0.24
	Barrow	(col)	T	T	T	0.01	0.02	0.03
	Cold Bay	(col)	0.02	0.19	0.64	0.19	0.42	0.79
	Fairbanks	(col)	0.04	0.02	0.14	0.11	0.07	0.55
	Juneau	(col)	0.42	0.37	0.38	0.53	0.60	0.56
	Nome	(col)	NS	T	0.02	NS	[a] 0.03	[a] 0.03
Calif:	W. Los Angeles	(pot)	0.76	0.08	0.35	1.21	0.15	0.63
	Palo Alto	(pot)	0.37	0.13	0.34	0.44	0.02	0.04
	San Francisco	(col)	0.42	0.10	0.37	0.58	0.01	0.01
Colo:	Denver	(col)	0.04	0.06	0.18	0.24	0.61	0.94
Fla:	Coral Gables	(pot)	0.18	[a] 0.28	[a] 0.27	[a] 0.27	0.15	0.19
	Miami	(col)	0.15	0.10	0.32	0.05	0.21	0.64
Hawaii:	Hilo	(col)	1.24	0.72	1.44	1.72	NS	2.68
	Honolulu	(pot)	0.29	0.50	0.52	0.02	0.14	0.01
	Lihue	(col)	0.30	0.34	0.32	0.45	0.57	0.33
	Mauna Loa	(col)	0.16	0.06	0.09	0.18	0.27	0.08
Ill:	Argonne	(pot)	0.42	0.17	0.08	0.78	0.38	0.68
La:	New Orleans	(col)	0.19	0.37	0.19	0.14	0.36	0.54
Minn:	International Falls	(col)	T	0.05	0.04	0.85	0.65	1.56
Mo:	Columbia	(col)	0.43	0.20	0.83	0.23	0.42	1.51
Mont:	Helena	(col)	0.05	0.05	0.15	0.22	0.71	1.13
N.J:	Westwood	(pot)	0.42	0.66	0.54	0.87	0.51	1.10
N.Y:	New York	(pot)	0.38	0.76	0.82	1.01	0.43	0.63
N. Dak:	Williston	(col)	0.09	T	0.02	0.31	1.11	0.71
Ohio:	Wooster	(pot)	0.51	0.09	0.08	0.80	0.08	0.40
Okla:	Midwest City	(pot)	0.14	0.54	0.15	0.55	1.22	1.10
	Tulsa	(pot)	NS	NS	NS	NS	3.80	0.41
Ore:	Medford	(col)	0.61	0.10	0.20	0.24	0.15	0.29
S.C:	Columbia	(col)	0.19	T	0.93	0.02	0.39	0.78
S. Dak:	Vermillion	(pot)	0.06	0.03	0.61	0.83	2.61	1.79
Tenn:	Chattanooga	(pot)	0.38	0.54	0.82	0.89	0.66	0.64
Tex:	Dallas	(col)	0.14	0.35	0.23	0.32	1.62	0.55
	El Paso	(col)	0.01	0.05	0.05	T	0.10	0.42
	Houston	(col)	0.09	T	0.39	0.30	0.83	0.63
Utah:	Salt Lake City	(pot)	0.52	NS	0.32	0.78	1.56	0.30
Va:	Sterling	(col)	0.20	0.29	0.51	0.73	0.61	0.59
Wash:	Seattle	(pot)	0.50	1.23	0.32	0.71	0.43	0.21
	Seattle	(pot)	0.56	0.36	0.01	0.45	0.44	0.29
	Tatoosh Island	(col)	0.50	1.13	0.37	0.85	0.32	0.05
Wis:	Appleton	(pot)	0.16	0.14	0.54	1.47	1.24	0.78
	Green Bay	(col)	0.13	0.13	0.32	1.07	1.04	0.27

[a] Proportioned from originally consolidated data.
NS, no sample reported.
T, zero or trace.

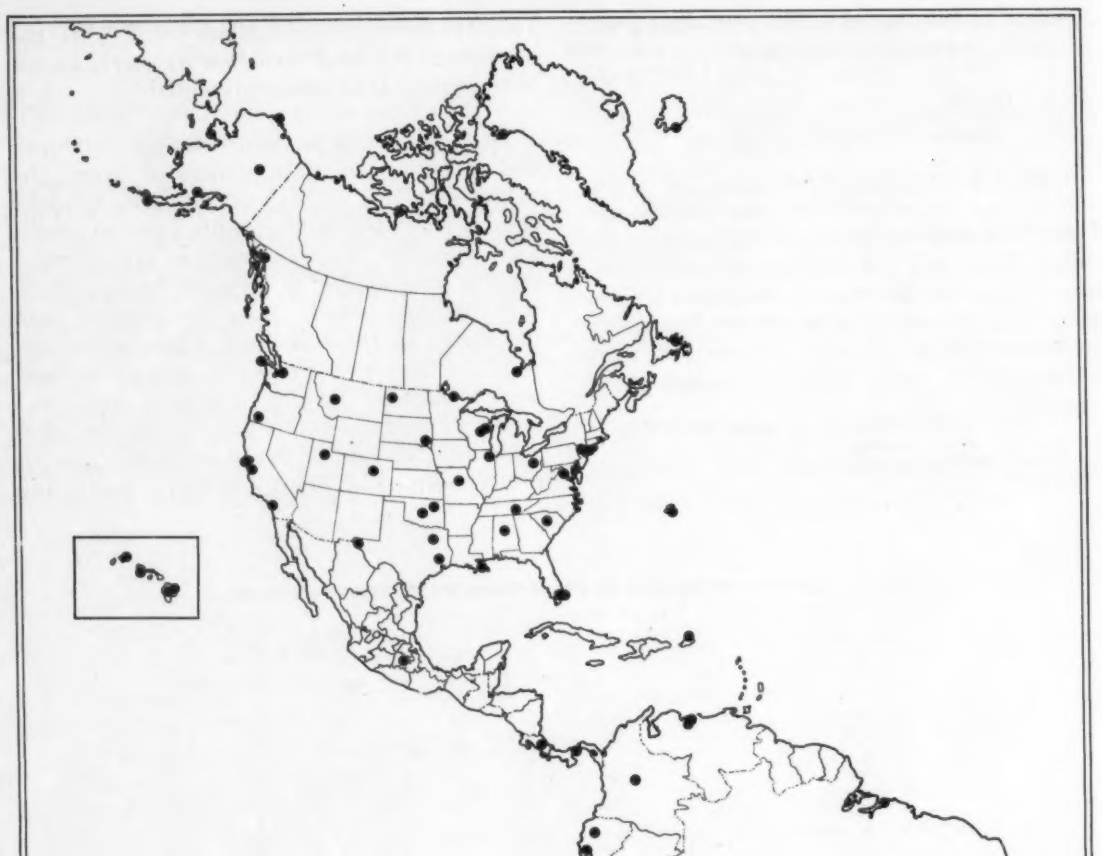

Figure 5. HASL fallout sampling stations in the Western Hemisphere

Table 5. Strontium-90 fallout in North and South America, HASL, January–June 1965

Sampling location and type of collection		Deposition in nCi/m²					
		Jan	Feb	Mar	Apr	May	June
Argentina:	Buenos Aires (col)	0.18	0.31	0.09	0.09	0.04	0.07
	Formosa (col)	0.11	0.20	0.06	0.11	0.06	0.03
	Malargue (col)	0.37	0.07	0.10	0.08	0.12	0.32
Bermuda:	Kindley AFB (col)	0.50	0.41	0.42	0.69	0.22	0.41
Bolivia:	Chacaltaya (col)	0.08	0.06	0.02	0.02	0.01	T
	La Paz (Ovejuyo) (col)	0.12	0.02	0.05	0.02	0.01	0.004
	La Paz (city) (col)	0.08	0.03	0.07	0.02	0.01	0.01
Brazil:	Belem (col)	0.13	0.14	0.08	0.17	0.06	0.08
	Brasilia (pot)	T	T	0.01	T	T	T
	Itaici Sao Paulo (pot)	NS	[a] 0.07	[a] 0.07	NS	0.05	0.02
	Nova Friburgo (pot)	NS	0.15	0.10	0.08	0.03	0.02
	Rio de Janeiro (col)	0.30	0.24	0.21	0.15	0.25	0.10
	San Jose dos Campos (pot)	0.02	0.18	0.07	0.02	0.02	NS
	Sao Leopoldo (pot)	0.25	0.09	0.20	0.09	0.06	0.16
	Trindade Island (col)	NS	NS	0.22	0.02	0.17	0.05
Canada:	Newfoundland (col)	0.12	0.04	0.04	0.08	0.08	0.55
	Moosonee (col)	0.02	0.03	0.01	0.16	0.66	0.59
Canal Zone:	Miraflores (col)	T	0.04	0.004	NS	0.12	0.70
Chile:	Antofagasta (col)	T	T	0.004	T	0.004	0.03
	I. Alejandro Selkirk (col)	0.13	0.05	0.17	0.15	0.45	0.03
	Easter Island (col)	0.19	0.13	0.26	0.16	0.22	0.06
	Puerto Montt (col)	0.29	0.32	0.09	0.25	0.27	0.19
	Punta Arenas (col)	0.09	0.25	0.12	0.08	0.07	NS
	Santiago (pot)	0.004	T	1.00	0.13	0.11	0.004
	Santiago (col)	0.02	0.03	0.02	0.21	0.10	0.15
Colombia:	Bogota (pot)	0.01	NS	NS	0.004	[a] 0.02	[a] 0.02
Costa Rica:	Turrialba (col)	0.27	0.08	0.01	0.12	0.08	0.25
Ecuador:	Guayaquil (col)	0.07	NS	0.10	0.10	NS	NS
	Quito (col)	0.01	0.004	0.04	0.01	0.02	0.40
Greenland:	Thule (col)	0.01	0.03	0.02	0.02	0.42	0.07
Iceland:	Keflavik (col)	0.04	0.04	0.23	0.21	0.33	0.24
Mexico:	Mexico City (col)	[a] 0.03	[a] 0.04	0.02	0.07	0.04	0.19
Peru:	Lima (col)	0.04	T	0.02	[a] 0.02	[a] 0.02	[a] 0.01
	Lima (col)	T	0.01	0.01	0.02	0.03	0.02
Puerto Rico:	San Juan (col)	T	0.02	0.11	0.26	1.22	0.99
Venezuela:	Caracas (site 1) (col)	0.05	0.02	0.03	0.07	0.03	0.19
	Caracas (site 2) (col)	0.05	T	0.05	NS	NS	NS

[a] indicates proportioned from originally consolidated data.
T, zero or trace.
NS, no sample reported.

data have been made, they are so indicated. In every case the best estimate of the true strontium–90 deposition is listed.

Other radionuclides

Laboratories at Westwood, New Jersey; Chattanooga, Tennessee; Seattle, Washington; Appleton, Wisconsin; Palo Alto, California; and Midwest City, Oklahoma, have analyzed monthly pot samples for various radionuclides. The amount of precipitation at each station and the monthly deposition rates for strontium–89, strontium–90, cesium–137, cerium–144, zirconium–95, manganese–54, and iron–55 at each station are presented in table 6.

Methods of collection

Two methods of fallout collection are employed by HASL. In the first, precipitation and dry fallout are collected for a period of 1 month in a stainless steel pot with an exposed area of 0.076 m². At the end of the collection period, the contents are transferred, by careful scrubbing with a rubber spatula, to a polyethylene sample bottle which is then shipped to the laboratory for analysis.

The second method involves the use of a polyethylene funnel, with an exposed area of 0.072 m², attached to an ion exchange column. After a 1-month collection, the inside of the funnel is wiped with a tissue, and the tissue is inserted in the end of the column, which is then sealed and sent to HASL for analysis. It has been shown that at the 95-percent-confidence level there was no significant difference in the strontium–90 measurements obtained from samples collected by the two methods (*1*).

Table 6. Radiochemical analyses of pot fallout samples at 6 U.S. sites, HASL fission product and "tracer" radionuclides in monthly collections, January-June 1965

Sampling location	Precipitation, mm						Strontium-89, nCi/m²					
	Jan	Feb	Mar	Apr	May	June	Jan	Feb	Mar	Apr	May	June
California, Palo Alto	74.2	19.3	38.9	27.9	T	T	0.02	0.01	NS	NS	NS	NS
New Jersey, Westwood	64.0	77.2	39.6	46.0	34.0	49.8	NS	NS	NS	NS	NS	NS
Oklahoma, Midwest City	50.5	28.7	31.0	66.3	86.1	49.8	<0.004	0.03	NS	NS	NS	NS
Tennessee, Chattanooga	82.8	119.4	254.0	98.6	71.1	107.7	NS	NS	NS	NS	NS	NS
Washington, Seattle	148.1	110.5	19.6	90.4	12.7	9.7	NS	NS	NS	NS	<0.05	0.44
Wisconsin, Appleton	17.3	19.3	80.0	95.5	59.9	81.5	NS	NS	NS	NS	NS	NS
	Strontium-90, nCi/m²						Manganese-54, nCi/m²					
California, Palo Alto	0.37	0.13	0.34	0.44	0.02	0.04	4.86	2.10	1.77	5.02	0.54	0.91
New Jersey, Westwood	0.42	0.66	0.54	0.87	0.51	1.10	4.05	6.68	3.94	5.29	4.44	5.29
Oklahoma, Midwest City	0.14	0.54	0.15	0.55	1.22	1.10	1.81	5.21	2.18	3.23	10.7	12.4
Tennessee, Chattanooga	0.38	0.54	0.82	0.89	0.66	0.64	3.81	3.39	4.63	4.86	4.94	3.33
Washington, Seattle	0.50	1.23	0.32	0.71	0.43	0.21	4.83	8.41	3.49	6.14	4.25	1.03
Wisconsin, Appleton	0.17	0.14	0.54	1.47	1.24	0.78	1.81	0.76	3.45	9.53	8.30	NS
	Iron-55, nCi/m²						Zirconium-95, nCi/m²					
California, Palo Alto	5.06	1.85	3.57	4.28	1.12	1.10	<0.004	<0.004	<0.03	<0.03	<0.09	NS
New Jersey, Westwood	4.86	7.10	4.94	4.48	4.55	6.95	0.16	<0.04	<0.03	<0.06	0.35	0.82
Oklahoma, Midwest City	2.44	2.37	2.51	5.13	10.2	8.18	<0.004	<0.004	<0.02	<0.01	1.06	NS
Tennessee, Chattanooga	6.18	4.79	9.50	6.37	4.40	5.75	<0.14	<0.05	<0.06	<0.03	0.69	0.66
Washington, Seattle	3.56	10.3	4.59	7.57	4.44	2.04	0.01	0.02	0.02	<0.02	<0.01	0.60
Wisconsin, Appleton	1.91	1.62	4.52	8.26	6.76	5.02	<0.12	<0.19	<0.02	<0.04	2.73	0.36
	Cesium-137, nCi/m²						Cerium-144, nCi/m²					
California, Palo Alto	0.45	0.19	0.46	0.54	0.06	0.08	1.71	0.59	1.31	1.52	0.17	0.24
New Jersey, Westwood	0.71	1.11	0.64	1.23	0.68	1.42	2.47	2.71	2.23	3.90	1.91	3.94
Oklahoma, Midwest City	0.20	0.68	0.24	0.65	1.56	1.48	0.67	1.93	0.84	1.79	3.85	4.28
Tennessee, Chattanooga	0.65	0.89	0.92	1.22	1.13	0.81	2.39	2.94	3.61	NS	2.57	2.83
Washington, Seattle	0.78	1.55	0.51	0.94	0.59	0.25	3.01	5.52	1.81	2.59	1.69	0.90
Wisconsin, Appleton	0.22	0.22	0.60	2.08	1.41	1.02	1.28	0.80	2.49	0.66	4.40	3.17

T, trace or zero
NS, no sample reported

REFERENCES

(*1*) LOCKHART, L. B., JR., and R. L. PATTERSON, JR. Intercalibration of the major North American networks employed in monitoring airborne fission products, NRL Report 6025. Naval Research Laboratory, Washington, D.C. 20390 (December 1963); summarized in Rad Health Data 5:12–15 (January 1964).

(*2*) RADIATION SURVEILLANCE NETWORK. Monthly tabulation of findings. Division of Radiological Health, Public Health Service, Washington, D.C. 20201 (distribution by official request).

(*3*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1959 on the Radioactive Fallout Study Program. CNHW–RP–3, Department of National Health and Welfare, Ottawa, Canada (May 1960).

(*4*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program. CNHW–RP–4, Department of National Health and Welfare, Ottawa, Canada (December 1961).

(*5*) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program. CNHW–RP–5, Department of National Health and Welfare, Ottawa, Canada (December 1962).

(*6*) BEALE, J., and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program. RPD–11, Department of National Health and Welfare, Ottawa, Canada (July 1962).

(*7*) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada. RPD–21, Department of National Health and Welfare, Ottawa, Canada (August 1962).

(*8*) CANADIAN DEPARTMENT OF NATIONAL HEALTH AND WELFARE. Canadian air and precipitation monitoring, August 1965. Rad Health Data 6:671–672 (December 1965).

Section IV. Other Data

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included are such data as those obtained from human bone sampling, bovine thyroid sampling, and environmental monitoring reports.

ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

Summaries of the environmental radioactivity data follow for the Lawrence Radiation Laboratory and the Mound Laboratory.

[1] Part 20, "Standards for Protection Against Radiation," AEC Rules and Regulations, contains essentially the standards published in the "AEC Manual." The AEC Rules and Regulations are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, on a subscription basis at $3.50 for 3 years.

1. Lawrence Radiation Laboratory January–June, 1965[2]

University of California
Berkeley, California

Berkeley Site

The Berkeley site of the Lawrence Radiation Laboratory (LRL) is located to the east of the University of California campus (figure 1). Technical facilities include a 6.3-BeV proton accelerator (Bevatron), a 700-MeV cyclotron, a 10-MeV linear accelerator, an 88-inch cyclotron, and various chemistry and physics laboratories.

The environmental sampling program includes monitoring of the atmosphere, surface and ground waters, sewage, and rain or dry deposition. Three types of atmospheric samples are taken: stack samples, local area samples, and perimeter samples.

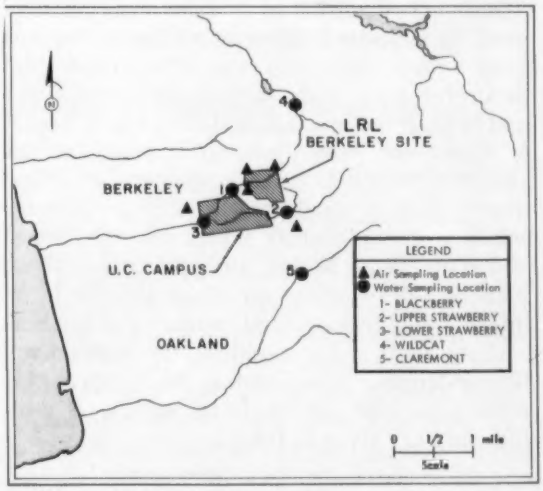

Figure 1. Environmental sampling locations at the Berkeley site

Approximately 110 "stacks" with potential for releasing radioactive contaminants are sampled continuously. One-inch-diameter filters are used at a flow rate of 1 liter per minute. The filters are changed weekly and counted for beta

[2] Summarized from "Results of Environmental Radioactivity Sampling Program," Lawrence Radiation Laboratory, first half 1965.

activity by an end-window Geiger-Mueller tube and for alpha activity by a thin-window proportional counter. Local area and perimeter air samples are taken at locations on the Laboratory site and at the property line, respectively. The samples are taken on 4- by 9-inch HV-70 filter paper at 4 cfm. The filters are changed weekly, counted for alpha activity by a thin-window proportional counter, and for beta activity by a 30 mg/cm^2–window Geiger-Mueller tube. A 40 percent loss in the alpha count is assumed for self absorption. The average levels of activity observed in each type of sample are given in table 1.

Table 1. Atmospheric monitoring, Berkeley site January–June 1965

Samping locations	Number of samples	Average concentrations (pCi/m^3)	
		Alpha	Beta
Stacks	4,000	ND	3.54
Local area	242	ND	0.37
Perimeter	97	ND	0.40

ND, not detectable

Rain or deposition samples are collected monthly in 18-inch diameter cylindrical vessels lined with polyethylene bags at local area and perimeter sites. Rain samples are poured out and evaporated in beakers. If the bag is dry, it is rinsed out with dilute nitric acid, and the resulting solution is then evaporated. Final evaporation is conducted in 2-inch diameter stainless-steel planchets, which are then flamed and coated with a thin film of lacquer. These planchets are counted for alpha activity in an internal-flow proportional counter and for beta activity with a thin-window, low-background Geiger-Mueller flow counter. No correction is made for self-absorption in the sample. Deposition data are given in table 2.

Table 2. Total deposition, Berkeley site January–June 1965

Location	Number of samples	Average concentrations (nCi/m^2)	
		Alpha	Beta
Local area	60	0.093	23.16
Perimeter	23	0.093	22.00

Water samples are taken from sewers, onsite streams, and offsite streams. Two sewer lines serve the LRL area. The "Hearst" sewer receives waste from the larger part of the area. A sampling system takes a continuous proportional sample from the Hearst sewer as it leaves the Laboratory boundary. Samples are also taken of waste feeding into the Hearst sewer from Buildings 70, 70A, and 71. The "Strawberry" sewer receives waste from the southeast part of the Laboratory site. A monitoring station for this sewer is under construction but has not yet been put into operation. Building 74 is the most likely contributor of radioactivity to this sewer line. The two acid waste systems from Building 74 are sampled individually on a continuous basis. Values reported for the Strawberry sewer are those obtained from Building 74. Strawberry and Blackberry Creeks comprise the Laboratory's storm drainage. These are sampled weekly at three locations. Two other nearby offsite streams are also sampled weekly. All water samples are handled in the same manner as rain samples. The results from the water sampling program are presented in table 3.

Table 3. Water monitoring, Berkeley site January–June 1965

Type of sample	Number of samples	Average concentration (pCi/liter)	
		Alpha activity	Beta activity
Sewage:			
Hearst sewer	65	0.73	22.2
Strawberry sewer	47	0.24	26.6
Tap water	24	0.04	4.6
Surface water:			
Onsite streams	74	1.5	13.7
Offsite streams	50	1.2	4.4

Livermore Site

The Livermore site of LRL (see figure 2) is located about 50 miles southeast of San Francisco, California. Technical facilities include a small cyclotron, a 2-megawatt swimming pool reactor, and physics and chemistry programs associated with a weapons development program.

An environmental sampling program is maintained to provide information regarding the

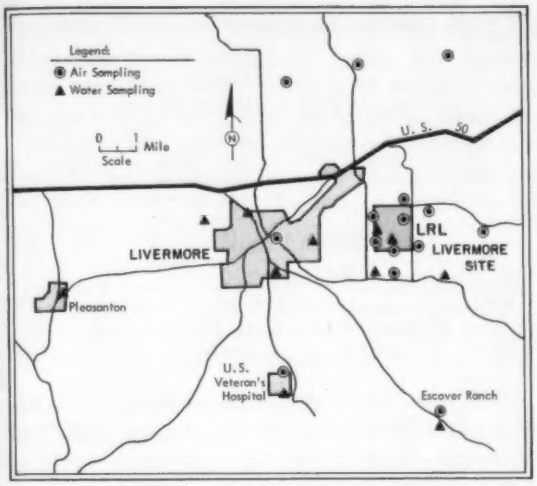

Figure 2. Sampling locations at the Livermore site

effectiveness of control measures and to determine whether any radiological changes in the environment are the result of laboratory operations. The sampling program includes air particulates, soil, domestic water, sewer effluent, and sewage plant products. Air samples are collected to ascertain that control efforts are restricting the release of radioactivity from the Laboratory to levels which do not exceed the permissible levels for the neighborhood around an atomic energy facility. The water samples are collected to monitor radioactivity in an underground water supply which provides most of the domestic water for the cities of Livermore and Pleasanton, and the sole supply for ranches in the Livermore and Amador Valleys.

Air samples are collected continuously at 15 sites within 5 miles of the Laboratory. Samples are collected at a rate of 4 cfm on 4- by 9-inch HV–70 filter papers, which are changed after every 7 days of operation. A minimum decay period of 96 hours is observed before the samples are counted to eliminate the effect of natural radon and thoron daughters. The alpha activity remaining is measured in a gas flow proportional counter with a counting efficiency of about 28 percent for 5.1 MeV alpha particles. The beta activity is measured in the same instrument using a strontium–90 in equilibrium with yttrium–90 source as the standard. The efficiency for beta particles is about 35 percent. Alpha activity in 357 air samples averaged 0.001 pCi/m^3, while beta activity averaged 0.17 pCi/m^3.

Domestic water samples are collected monthly from nine nearby areas. The alpha activity fluctuated from the limit of sensitivity (5.0 pCi/liter) to a high of 20.9 pCi/liter. The beta activity ranged from the limit of sensitivity (1.8 pCi/liter) to 105 pCi/liter. The average alpha concentration was 5.6 pCi/liter and the average beta concentration was 11.6 pCi/liter. The gas proportional counter used in these measurements has a counting efficiency of 34 percent for alpha emitters and 50 percent for beta emitters.

Samples are collected every Monday, Wednesday, and Friday at the sewer line leaving the southwest project boundary, where it connects with the Livermore domestic sewer line. Grab samples are collected monthly at the Livermore Sewage Disposal Plant to assure that the liquid effluent from the laboratory is not creating abnormal radioactivity concentrations either in the oxidation ponds (which overflow into a natural waterway) or in the dried sludge (which is used as an agricultural soil conditioner). Radioactivity levels in sewage oxidation ponds and dried sludge are summarized in table 4.

Table 4. Environmental sampling, Livermore January–June 1965

Type of sample	Average concentration	
	Alpha activity	Beta activity
Sewage (pCi/liter)	20	146
Oxidation ponds (pCi/liter)	39	77
Dried sludge (pCi/g)	39	41

Samples of top layer soil are collected quarterly at the 19 sampling stations surrounding the Livermore site. The alpha activity fluctuated from the minimum detectable level (1.5 pCi/g) to 13.0 pCi/g. The beta activity fluctuated from the minimum detectable level (3.5 pCi/g) to 53.0 pCi/g. The average alpha concentration was 2.4 pCi/g and the average beta concentration was 16.1 pCi/g. The concentrations are in the normal range for soil in the Livermore Valley.

Site 300

Site 300 (see figure 3), is located in a very

sparsely populated ranching area about 17 miles southeast of the Lawrence Radiation Laboratory at Livermore. Air and water samples

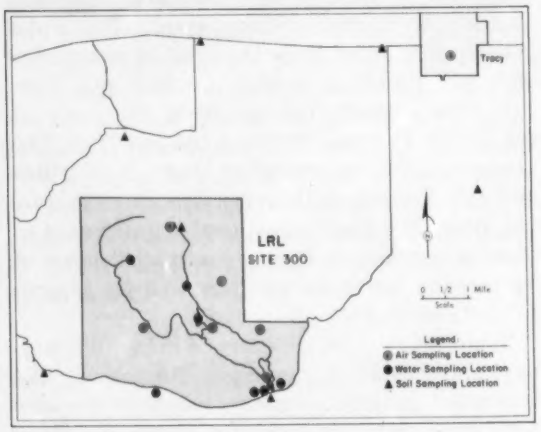

Figure 3. Sampling locations at Site 300, Lawrence Radiation Laboratory

are taken to determine whether operations at Site 300 are changing the normal radioactivity levels in the vicinity. The eight air samplers at Site 300 are operated at about 50 cfm on a continuous basis with the filter papers being changed on an irregular schedule. Most of these air samplers are located within the boundaries of the test site due to unavailability of power facilities offsite. Water samples are taken from six onsite wells because they are the only readily accessible sources of underground water. Samples are collected from streams only during the winter months, when water flow exists. Soil samples are collected monthly at nine offsite locations. Only top layer soil is collected to determine fallout concentrations. All air, water, and soil samples are processed at the Laboratory in Livermore. The average radioactivity levels in all types of samples are summarized in table 5.

Table 5. Environmental sampling, Site 300 January–June 1965

Type of sample	Average concentration	
	Alpha activity	Beta activity
Air (pCi/m³)	0.001	0.15
Water (pCi/liter)	ND	13
Soil (pCi/g)	5	10

ND, not detectable

Previous coverage in *Radiological Health Data and Reports:*

Period	*Issue*
July-December 1961	October 1962
Calendar Year 1962	October 1963
Calendar Year 1963	October 1964
January-June 1964	May 1965
July-December 1964	November 1965

2. Mound Laboratory January–June 1965[3]

Monsanto Research Corporation
Miamisburg, Ohio

Of the radionuclides in use at Mound Laboratory, only polonium–210, plutonium–239, and hydrogen–3 (tritium) are potential environmental contaminants. No measurable amounts of penerating radiation such as gamma or hard beta have been contributed to the environment by the Laboratory during the period covered by this report.

The environmental monitoring program, conducted by the Monsanto Research Corporation, is planned and coordinated with regard to all of the various projects performed in the Laboratory. Air and water monitoring methods and results are discussed below.

Air monitoring

A continuous air monitor for measurement of tritium, and particulate air-sampling equipment for measurement of alpha activity, are mounted on a 1-ton panel truck for use in the routine monitoring of the environmental air at 90 locations selected within a radius of 20 miles. The choice of sites on a given day depends on the wind direction at the time of collection.

During the 6-month period ending June 1965, 319 samples were taken for determination of tritium in air. In all cases tritium was nondetectable.

Monitoring for possible polonium–210 and plutonium–239 released to the environment is accomplished by determination of long-lived gross alpha activity of filter paper samples. Counting is done in a low-background proportional counter. Sufficient delay time is allowed

[3] Summarized from "Environmental Monitoring Report: January–June 1965" (MLM–1275).

after collection to minimize interference from the daughter products of radon and thoron. The measured concentrations of alpha activity in air are summarized in table 6. Since the gross alpha activity remained substantially below the environmental limits for these nuclides, specific determinations of polonium–210 or plutonium–239 were not made.

Table 6. Long-lived alpha concentrations in air in the Mound Laboratory environment, January–June 1965

Direction from laboratory relative to wind	Number of samples	Average concentration (pCi/m^3)
Upwind	52	0.0036
Downwind	311	0.0028

Water monitoring

Liquid radioactive waste materials from polonium and plutonium operations at the Laboratory are processed in special waste disposal plants designed to reduce radioactivity to a concentration level at which it may be discharged to the Great Miami River.

Helium–3, which is purified at the Mound Laboratory, contains small quantities of tritium. Liquid waste from this work, small in volume, is treated (diluted with water when necessary) to assure that the radioactivity content is below the maximum permissible concentration before discharge to the Great Miami river.

Weekly water samples are collected from a drainage ditch and five locations along the Great Miami river as shown in figure 4. Additional samples are taken quarterly at distant downstream points. The drainage ditch carries away all storm sewer water and liquid tritium and treated plutonium wastes from the plant site. Sampling location number 2 is located at the point of discharge of the laboratory effluent to the Great Miami River, and number 6 is 5 miles downstream from the effluent outlet.

All of the river samples are analyzed for polonium–210. The drainage ditch samples and some of the river samples are analyzed for tritium. The drainage ditch samples are also analyzed for plutonium–239. Average concentrations of tritium, polonium–210, and plutonium–239 are given in table 7.

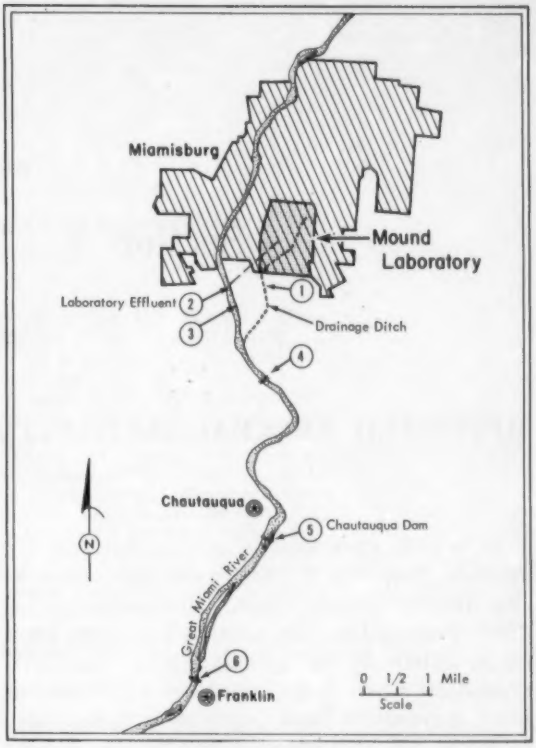

Figure 4. Water sampling locations in Great Miami River, Mound Laboratory

Table 7. Offsite water monitoring for polonium-210, tritium, and plutonium-239 from Mound Laboratory, January–June 1965

Nuclide and sampling station	Number of samples	Average concentration (pCi/liter)
Polonium-210		
2 (effluent) (see figure 3)	21	7.2
3 (250 yards downstream)	21	1.8
4	21	0.4
5	21	1.4
6	21	0.9
Trenton, Ohio	2	0.4
New Miami, Ohio	2	0.9
7 miles upstream from New Baltimore, Ohio	2	0.9
New Baltimore, Ohio	2	0.9
Miamitown, Ohio	2	0.0
Elizabethtown, Ohio	2	0.4
Hydrogen-3 (tritium)		
1 (drainage ditch)	21	300,000
2 (effluent)	21	<100,000
4	21	<100,000
Plutonium-239		
1 (drainage ditch)	22	208

Previous coverage in *Radiological Health Data:*

Period	*Issue*
January-June 1962	March 1963
July 1962–June 1963	April 1964
July-December 1963	November 1964
January-June 1964	May 1965
July-December 1964	November 1965

Section V. Technical Notes

REPORTED NUCLEAR DETONATIONS, APRIL 1966

Five U.S. underground nuclear tests at the Nevada Test Site (NTS) were announced by the Atomic Energy Commission during April 1966. Tests of low yield (equivalent to the force of less than 20 kilotons of TNT) were conducted on April 1, 6, 7, and 25; and a test of low-intermediate yield (equivalent to the force of 20 to 200 kilotons of TNT) was conducted on April 14.

The Commission also announced that the United States has recorded seismic signals which originated in the Soviet nuclear testing area in the Semipalatinsk Region. The signals were equivalent to those of a nuclear test in the low-yield range.

Preliminary information from the NTS surveillance system indicates that a small amount of radioactive material was detected offsite following two 1966 underground nuclear tests. An underground test conducted on March 5 released radioactivity to the atmosphere that was just detectable in the nearby offsite populated area by external gamma monitoring and in ground-level air filter samples. Observations on the test of April 25 showed measurable amounts of radioactivity on the ground and in milk to the northeast of the site. This prompted AEC to recommend that some milk cows in the area be put on dry feed for about 16 days. Subsequent measurements of radioactivity in the thyroid glands of 71 children and 9 adult residents in nearby villages resulted in total dose estimates ranging from 50 to 100 millirads for 14 individuals, to a maximum of 250 to 300 millirads for 5 individuals, based on iodine present in their thyroid glands at the time of measurement. Additional intake of iodine–131 was expected from milk consumed after the time of thyroid counting, but this would not greatly increase the total thyroid dose.

SYNOPSES

Synopses of reports are presented below for reference card format for the reader's convenience.

DISPOSAL OF RADIOACTIVE WASTES FROM U.S. NAVAL NUCLEAR-POWERED SHIPS AND THEIR SUPPORT FACILITIES. J. *W. Vaughan* and *M. E. Miles* (Department of the Navy). *Radiological Health Data and Reports, Vol. 7, May 1966*, pp. 257–262.

This report summarizes data on disposal of radioactive wastes from U.S. Naval nuclear-powered ships and their support facilities and summarizes results of environmental monitoring performed to confirm adequacy of waste disposal limits and procedures. The waste disposal data presented show that the total long-lived radioactivity in liquid waste discharges associated with operation and maintenance of Naval nuclear-powered ships has been less than 2 curies per year in any harbor. Results of environmental surveys of harbor water and bottom sediment for gross radioactivity and for cobalt–60 have shown that (1) no increase in radioactivity above normal background levels has been detected in harbor water, (2) discharges of liquid wastes from U.S. Naval nuclear-powered ships have not caused a measurable increase in the general background radioactivity of the environment, and (3) low-level cobalt–60 radioactivity has been detected in localized areas of harbor bottom sediment around a few piers at operating bases and shipyards where maintenance and overhaul of Naval nuclear-powered ships has been conducted over a period of several years.

This report confirms that procedures issued by the Navy to control discharges of radioactivity from U.S. Naval nuclear-powered ships and their support facilities are effective in protecting the health and safety of the general public. These Navy procedures, which have been reviewed and concurred in by the U.S. Public Health Service and the U.S. Atomic Energy Commission, contain discharge limits which are consistent with applicable recommendations of the Federal Radiation Council, U. S. Atomic Energy Commission, and International Commission on Radiological Protection.

KEY WORDS: cobalt–60, environmental survey, harbors, liquid wastes, nuclear-powered ships, radioactivity, sediments, support facilities, waste disposal.

THE GALVESTON ENVIRONMENTAL SURVEILLANCE PROGRAM. *D. H. Flora* and *M. C. Wukasch* (Texas State Department of Health). *Radiological Health Data and Reports*, Vol. 7, May 1966, pp. 263–267.

Environmental surveillance between March 10 and August 20, 1965, at the Galveston refueling and servicing site for the Nuclear Ship Savannah indicated no detectable radioactive contamination attributable to the ship's operations. Surveillance activities, which have continued at this site since July 1962, include air, rain, seawater, silt, shellfish (oysters), and milk sampling. During the Savannah's 1965 visit, almost all analytical results for environmental samples were close to or below detectable limits, except for milk. Radioactivity trends in milk samples at this time closely followed the nationwide trend reported by the U.S. Public Health Service.

KEY WORDS: air, alpha, barium–140, beta, cesium–137, environmental, Galveston, gamma, iodine–131, milk, nuclear ship, radionuclides, rain, seawater, silt, U.S. Savannah, strontium–89, strontium–90, Texas.

ORDER BLANK FOR RHD&R

To: Superintendent of Documents
Government Printing Office
Washington, D.C. 20402

Please enter my Subscription for Radiological Health Data and Reports. I am enclosing Money Order ☐ Check ☐ for this subscription. ($5.00 a year; $1.50 additional for foreign mailing.)

Please address RHD&R as follows._____

_____

_____

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON, D.C., 1965

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402
Subscription price $5.00 a year, $1.50 additional for foreign mailing.
Price for a single copy of this issue is 50 cents.

May 1966

SYMBOLS, UNITS, AND EQUIVALENTS

Symbols	Units	Equivalents
BeV	billion electron volts	equals GeV
Ci	curie	3.7×10^{10} dps
cm	centimeter(s)	0.394 inch
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volts	1.6×10^{-12} ergs
g	gram(s)	
GeV	giga electron volts	1.6×10^{-3} ergs
kg	kilogram(s)	1,000 g = 2.205 lb
km^2	square kilometer(s)	
kVp	kilovolt peak	
m^3	cubic meter(s)	
mA	milliampere(s)	
mCi/mi^2	millicuries per square mile	0.386 nCi per square meter (mCi/km^2)
MeV	million (mega) electron volts	1.6×10^{-6} ergs
mg	milligram(s)	
mi^2	square mile(s)	
ml	milliliter(s)	
mm	millimeter(s)	
nCi/m^2	nanocuries per square meter	2.59 mCi per square mile
pCi	picocurie(s)	10^{-12} curie = 2.22 dpm
R	roentgen	
rad	unit of absorbed radiation dose	100 ergs per gram

INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr' a
10^{9}	giga	G	jĭ' ga
10^{6}	mega	M	mĕg' a
10^{3}	kilo	k	kĭl' o
10^{2}	hecto	h	hĕk' to
10	deka	da	dĕk' a
10^{-1}	deci	d	dĕs' i
10^{-2}	centi	c	sĕn' ti
10^{-3}	milli	m	mĭl' i
10^{-6}	micro	μ	mi' kro
10^{-9}	nano	n	năn' o
10^{-12}	pico	p	pē' co
10^{-15}	femto	f	fĕm' to

U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
WASHINGTON D.C. 20201

OFFICIAL BUSINESS

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF H.E.W.

If you do not desire to continue receiving this publication, please CHECK HERE ☐; tear off this label and return it to the above address. Your name will then be promptly removed from the appropriate mailing list.

Documents Section
University of Rochester Library
River Campus Station
Rochester, N.Y. 14627

RH-5
1-ah